

ANTI - FRICTION LINESHAFT BEARINGS

BY

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ARMOUR INSTITUTE OF TECHNOLOGY

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lineshaft bearings

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A STUDY OF
**ANTI-FRICTION LINESHAFT
BEARINGS**

A THESIS

PRESENTED BY

**ARTHUR KATZINGER
ARTHUR S. ALTER**

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

HAVING COMPLETED THE PRESCRIBED COURSE OF STUDY IN

MECHANICAL ENGINEERING

MAY 25, 1916

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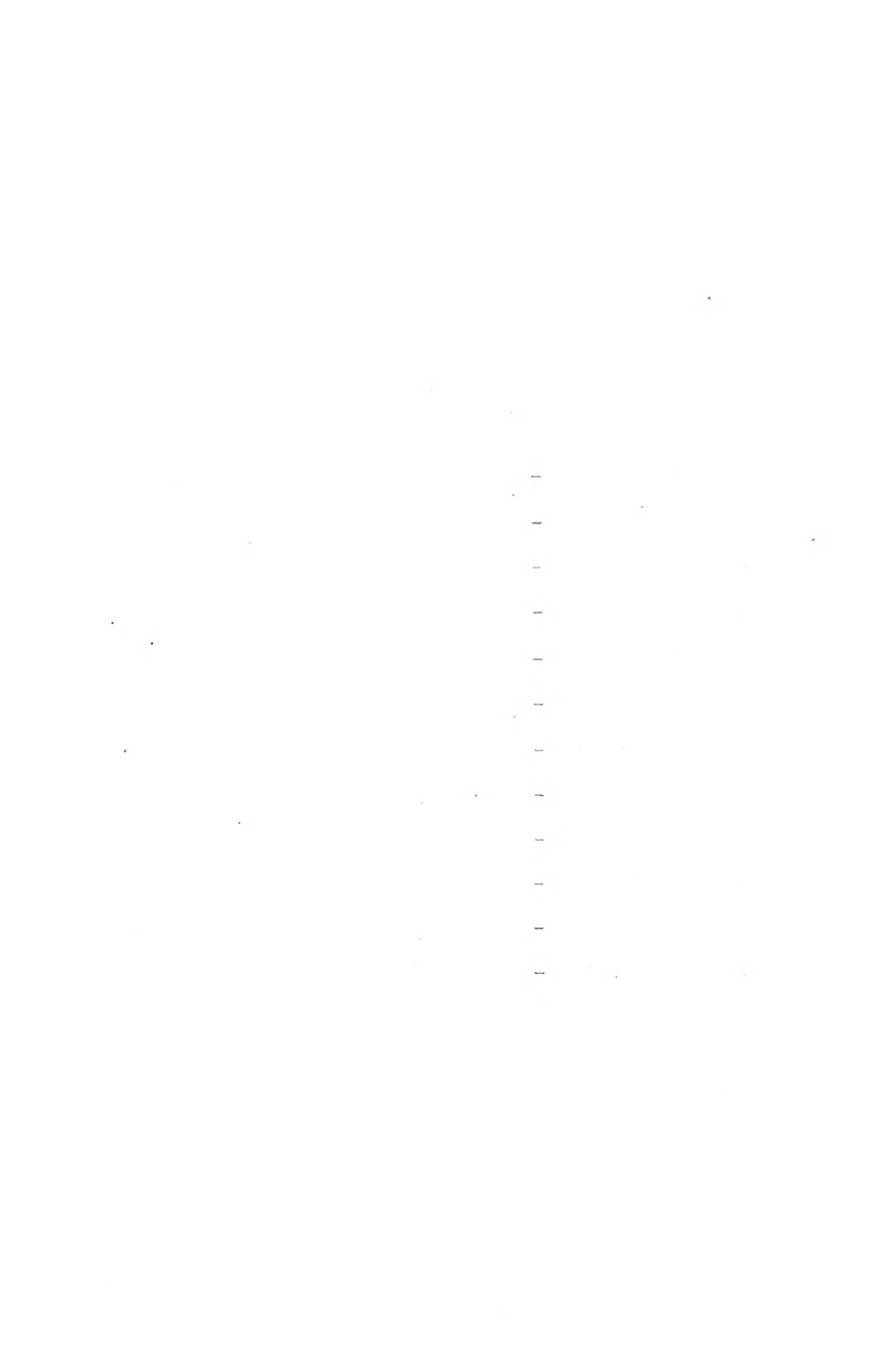
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INTRODUCTION

INTRODUCTION

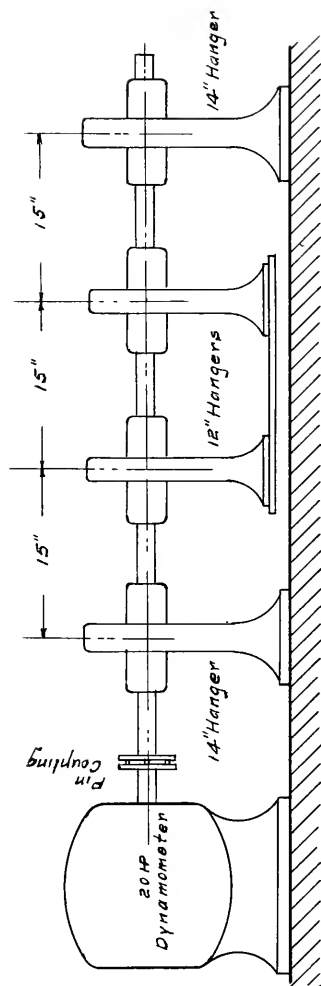
The object of this test is the determination of the coefficient of friction and the horse power necessary to drive various types of line shafting bearings. Much research work has been done along these lines, but, no information is available which compares in a logical manner babbitt, roller and ball bearings.

In conducting these tests, the three types of bearings were operated at various loads and speeds varying from maximum to minimum. The power input was determined by means of a carefully calibrated reaction dynamometer and the coefficient of friction was calculated from the resulting data.

The bearings tested were: one ball, three roller and one babbitt. The method of procedure for one bearing was exactly the same for another. In each case the amount and kind of lubricant called for by the manufacturers of the bearings

was used. Before mounting a set of bearings on the shaft each one was thoroughly cleaned and the lubricant replaced.

ARRANGEMENT OF APPARATUS
AND
METHOD OF TESTING



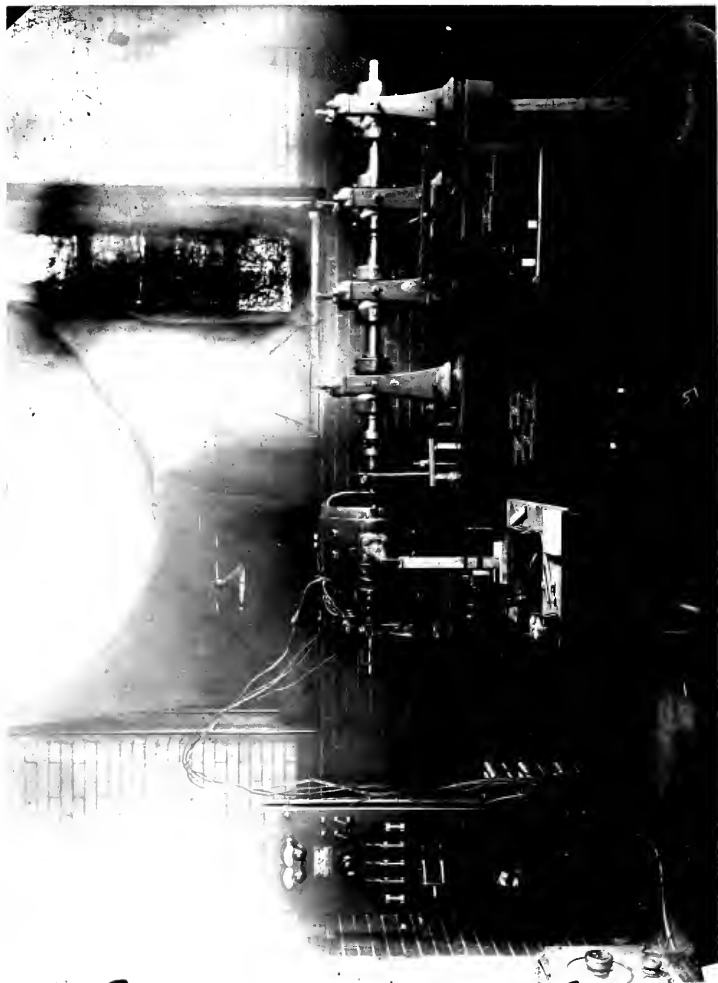


Fig. 2



ARRANGEMENT OF APPARATUS AND METHOD OF TESTING.

Two of the bearings were mounted in 14 inch hangers, and these hangers were bolted to a surfaced steel table and placed 45 inches from each other. The other two bearings were mounted in 12 inch hangers and spaced 15 inches center to center and midway between the first two hangers.(Fig.1)

A plate was bolted on the bottoms of the two middle hangers and served as a platform to receive the dead weight. The two central hangers were two inches shorter than the two outside hangers, thereby allowing the central unit to swing freely about the shaft.

The shaft was coupled to the 20 H.P. dynamometer. Two collars were placed on one of the center bearings and two on one of the end bearings to prevent end thrust travel.

All bearings were taken from the stock



intended for sale and were new. All sets were operated until the friction became constant. After these preliminary runs, the apparatus was allowed to stand over night so as to insure uniform temperature conditions for each set of tests.

The load was placed in carriers hung upon a stationary beam which rested on the plate supported by the two center hangers. The friction load was transmitted through the agency of the dynamometer arm to a sensitive scale.

The first load applied was 3000 pounds or 1500 pounds per bearing, and the speed of the shaft was the maximum which the bearing could stand. The speed was obtained by an electric speed counter and checked by a hand revolution counter. The load on the scale was read at the same time. The speed was then lowered a few hundred R.P.M. and the load on scale again read. This process was repeated until the shaft was going as slowly as the motor

would turn it. Then the load was reduced from 3000 to 2700 and the entire process repeated; about twelve readings being taken for each load from 1500 down to 300 in increments of 150 pounds. The load of 300 was the minimum since this represented the actual weight of the hangers, bearings, shaft and plate.

This completed the run for a set of bearings, but, in order to verify the results the shaft and bearings were allowed to cool off until the next morning and the test repeated.

The first part of the paper discusses the importance of the
 research and the objectives of the study. The second part
 describes the methodology used in the study. The third part
 presents the results of the study. The fourth part discusses
 the implications of the findings. The fifth part concludes the
 paper.

GENERAL THEORY

GENERAL THEORY

The load on the two center bearings consisted of, the weights of the two center bearings, the two center hangers, the cast iron plate and the added dead weight. The total load on the two end bearings was the above weight plus the weight of the shaft and coupling. The average load per bearing was, therefore, one-half of the weight of the two center bearings, the cast iron plate, the shaft and coupling, and the added weights. This is the load recorded in the tables, and ranges from 1500 pounds maximum to 300 pounds minimum.

All readings were taken simultaneously. The dynamometer was tested for balance before each new set of runs, thus insuring accuracy.

The torque was obtained by multiplying the force on the scale by the lever arm of the dynamometer, in our case $31\frac{1}{2}$ inches. This torque was in inch pounds, and repre-

sented the torque necessary to drive the four bearings and one-fourth of this was the torque necessary to drive one bearing.

The H. P. necessary to drive one bearing at any load and speed, was computed from the torque and speed by accepted methods:

$$\text{H.P.} = \frac{\text{Lbs.} \times \text{R.P.M.}}{2000}$$

The 2000 is the constant of this dynamometer.

The coefficient of friction was computed from the load and the torque. It is readily seen that the torque at the shaft is equal to the ratio of the lever arm of the dynamometer to the lever arm of the shaft, the radius, times the torque at the dynamometer arm, as follows:--

$$\text{No. Lbs. torque} \times \frac{31.5''}{\frac{1-7''}{32}} = \text{torque at shaft.}$$

The coefficient of friction is the torque at the shaft divided by the load.

$$\text{Coefficient of friction} = K. = \frac{\text{torque at shaft}}{\text{load}}$$

The coefficient of friction was computed in two ways. In the first method, as outlined on page 12, designated in the tables as "A", the actual radius of the shaft was used. In the second method, the radius of the ball or roller line circumference was used.

It is a difficult matter to decide which is the proper way to figure the coefficient. It can be seen from the formula for the coefficient of friction that the ball and roller bearings assume a decided advantage over the babbitt bearing by the use of method "B", inasmuch as the friction radius is increased by taking it as the distance from center of ball or roller to the center of shaft, and an increase in the friction radius decreases the coefficient of friction.

In most of the testing done to date, the coefficient of friction was usually figured by method "B", but, it is the opinion of the writers that it is unfair to the babbitt bearings and for that reason, a preference



has been given to method "A". In a ball or roller bearing, the friction really acts at the tracks on which the balls or rolls turn, but, for purposes of comparison with plain bearings, the friction is referred to the bearing bore, which is identical with the shaft diameter.

It is understood that a comparison of the coefficient of friction of bearings is necessary, but, at the same time, it should be understood that the coefficient of friction influences, not so much the amount of power to drive the shafting, as it influences the bearing itself. A high coefficient will shorten the life of the bearing, because a great quantity of rubbing and lashing will occur which will injure the bearing constituents. This will be used up energy changed to the form of heat, and it will ultimately cause an increase in the power necessary to drive. But, if an anti-friction bearing be properly designed, there is little danger of an excessive coefficient of friction and the usual

loss of power through heating.

For this reason, the truest comparison of bearings is to compare the horse power necessary to drive, and that the best bearing, is, the one which will run cold at any ordinary speed and load and require the least amount of power.

An important point in economic power transmission is lubrication. The manufacturers of babbitt bearings all recommend the use of machine oil, and in some instances, they have made tests to find out which oil was best suited to their bearing and how often and how much was required. But, when the anti-friction bearings came into use, the manufacturers maintained that ball and roller bearings should survive in the absence of lubrication, but, they now recommend the use of a lubricant, because, foreign matter in the raceways cannot be eliminated in any other way.

This does not necessarily mean that lubrication increases the efficiency of a

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properly designed ball or roller bearing, for the reverse is true, as has been illustrated by experiments. They will give a lower coefficient of friction when running clean and dry than when lubricated by even a thin oil.

In perfectly lubricated journal bearings, there is no metallic contact between surfaces, but, in the ball and roller bearings, there is always metallic contact.

The coefficient of friction for sliding contact is much higher than for rolling contact. The coefficient of rest and slow motion is much greater for sliding friction than for rolling.

CLASSIFICATION OF
BEARINGS TESTED

CLASSIFICATION OF BEARINGS TESTED

For all convenience in this work, each type of bearing tested is to be referred to by initial, as follows:--

BEARING

"A".....DUPLEX TAPER ROLLER.

"B".....HELICAL ROLLER.

"C".....BABBITTED RING OILED.

"D".....DOUBLE ROW SELF ALIGNING
BALL BEARING.

"E".....CYLINDRICAL PLAIN ROLLER.

1. The first part of the paper is devoted to the study of the asymptotic behavior of the solutions of the system of equations (1) as $t \rightarrow \infty$. It is shown that the solutions of this system tend to zero as $t \rightarrow \infty$ if and only if the matrix A is stable.

2. In the second part of the paper, the problem of the asymptotic stability of the solutions of the system (1) is considered. It is shown that the system (1) is asymptotically stable if and only if the matrix A is stable and the matrix B is nonsingular.

3. In the third part of the paper, the problem of the asymptotic stability of the solutions of the system (1) is considered. It is shown that the system (1) is asymptotically stable if and only if the matrix A is stable and the matrix B is nonsingular.

BEARING "A"

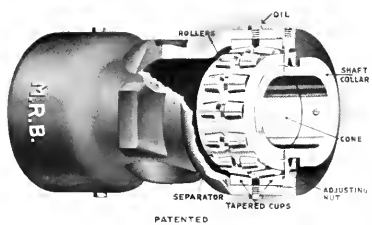


Fig. 3

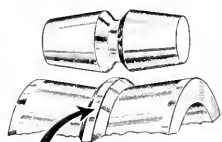


Fig. 4



Fig. 5

BEARING "A"

Bearing "A" (Figures 3,4,5) is a duplex roller bearing having as its chief feature, two sets of double tapered rollers. The housing of cast iron has a diameter sufficient to contain one set of rolls in each end.

A hardened steel cone fits on the shaft and revolves with it. The double tapered rolls run on this cone and are held central by means of a projection in the center of the cone which fits into the groove of the rolls. (Fig.4) The rolls are kept at a constant distance from each other by means of a bronze separator.

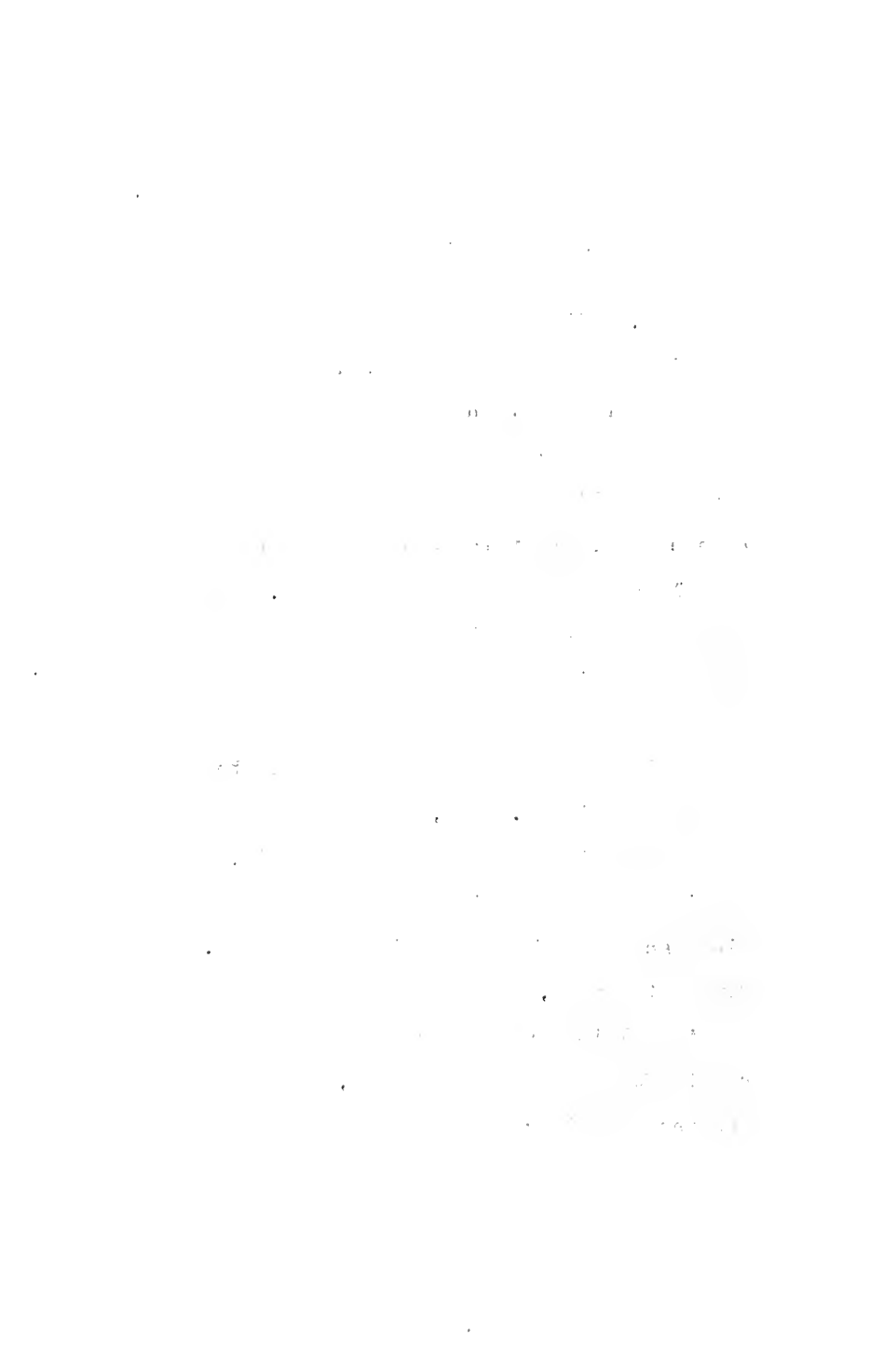
On the top of the rolls are two tapered cups arranged so that one is on the one taper of the roll and one on the other. These two tapered cups act as the upper raceway for the rolls.

The whole set fits inside one end of the housing, the end of which is threaded to accomodate a nut which when screwed in tightens



or loosens the tapered cups against the rolls. A set screw from the housing and onto the adjustment is tightened when the bearing is adjusted. Oil may be poured in through a hole in the top of the housing.

Bearing "A" being of the double taper type has in addition to the slippage due to misalignment and the slippage due to an area of contact instead of line contact, the slippage due to the double taper. This results from the fact that one laminae of the roll is revolving at a slightly greater or less speed than the next one due to its greater or less diameter, thus causing a slippage. But, the loss of power or increase in coefficient due to this, is negligible in comparison to the loss due to misalignment and irregularity of surface. For that reason, the firm manufacturing that bearing claims that after the bearing has been run in for two or three months, it runs at a greater efficiency due to the polish of the



surfaces and grinding out of the rough spots on the separator.

A good feature of Bearing "A", is, that it showed very little tendency toward the introduction of end thrust. The fact, that the collars which go with this bearing fit so that they revolve on the shaft and at the same speed as the bearing sleeve, eliminates any friction due to end thrust which is a most desirable feature.

The bearing did not heat up to any extent, except on such loads and speeds which very seldom are used for line shafting work. As can be seen by the data sheets and curves, this bearing was run at higher speed than any of the others. At the high speeds and loads, the grease ran hot, but, as a whole, the bearing ran remarkably cool.

Another good feature about this bearing is, its adaptability to adjustment.

TABLES 1 - 16
of
BEARING "A"

B E A R I N G A

Table No. 1 Date July 2nd, 1915.

Bearing Load, LBS. 1500 Time, beginning of run 8:20 A.M.

Room Temp.° Fahr. 75 Time, end of run 8:44 A.M.

Observers _____

NOTE:—All data average of four bearings.

POUNDS at 31½ in. radius	R. P. M.	TORQUE		Horse Power to Drive	COEFFICIENT OF FRICTION	
		Inch	Lbs.		Shaft	Bearing
0.55	1619	17.42		0.445	0.0095	0.0062
0.54	1513	17.00		0.408	0.0093	0.0061
0.535	1368	16.88		0.366	0.0092	0.0060
0.52	1148	16.40		0.298	0.0090	0.0058
0.505	876	15.91		0.219	0.0087	0.0056
0.52	806	16.40		0.208	0.0090	0.0058
0.525	679	16.57		0.178	0.0091	0.0059
0.535	611	16.88		0.163	0.0092	0.0060
0.55	501	17.42		0.138	0.0095	0.0062
0.57	372	17.98		0.106	0.0098	0.0064
0.62	212	19.56		0.066	0.0107	0.0069

Remarks:—

• • •

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B E A R I N G A

Table No. 2 Date July 2nd, 1915.

Bearing Load, LBS. 1350 Time, beginning of run 8:44 A.M.

Room Temp.° Fahr. 75 Time, end of run 9:06 A.M.

Observers _____

NOTE:—All data average of four bearings.

POUNDS at 31½ in. radius	R. P. M.	TORQUE		Horse Power to Drive	COEFFICIENT OF FRICTION	
		Inch	Lbs.		Shaft	Bearing
0.50	1743	15.75		0.436	0.0096	0.0062
0.485	1622	15.27		0.393	0.0093	0.0061
0.48	1446	15.11		0.347	0.0092	0.0060
0.47	1273	14.80		0.299	0.0090	0.0058
0.46	971	14.48		0.223	0.0088	0.0057
0.48	836	15.11		0.201	0.0092	0.0060
0.485	725	15.87		0.176	0.0093	0.0061
0.49	646	15.41		0.158	0.0094	0.0061
0.51	481	16.07		0.122	0.0098	0.0061
0.55	305	17.31		0.084	0.0105	0.0068
0.58	189	18.89		0.057	0.0115	0.0075

Remarks:—

B E A R I N G A

Table No. 3 Date July 2, 1915.

Bearing Load, LBS. 1200 Time, beginning of run 9:06 A.M.

Room Temp.° Fahr. 75 Time, end of run 9:23 A.M.

Observers _____

NOTE:—All data average of four bearings.

POUNDS at 31½ in. radius	R. P. M.	TORQUE		Horse Power to Drive	COEFFICIENT OF FRICTION	
		Inch	Lbs.		Shaft	Bearing
0.46	1863	14.50		0.429	0.0099	0.0064
0.445	1714	14.02		0.382	0.0096	0.0062
0.425	1502	13.36		0.319	0.0091	0.0059
0.405	1216	12.75		0.246	0.0087	0.0056
0.40	1002	12.60		0.200	0.0086	0.0056
0.405	878	12.75		0.178	0.0087	0.0056
0.405	781	12.75		0.158	0.0087	0.0056
0.405	709	12.75		0.144	0.0087	0.0056
0.415	566	13.06		0.118	0.0089	0.0058
0.48	286	15.12		0.069	0.0103	0.0067
0.52	181	16.38		0.047	0.0112	0.0073

Remarks:—

B E A R I N G A

Table No. 4 Date July 2nd, 1915.

Bearing Load, LBS. 1050 Time, beginning of run 9:23 A.M.

Room Temp.° Fahr. 75 Time, end of run 9:45 A.M.

Observers _____

NOTE:—All data average of four bearings.

POUNDS at 31½ in. radius	R. P. M.	TORQUE		Horse Power to Drive	COEFFICIENT OF FRICTION	
		Inch	Lbs.		Shaft	Bearing
0.47	1956	14.78	0.460	0.0116	0.0075	
0.43	1836	13.52	0.395	0.0106	0.0069	
0.405	1715	12.75	0.347	0.0100	0.0065	
0.39	1530	12.28	0.298	0.0096	0.0062	
0.385	1241	12.10	0.239	0.0095	0.0062	
0.325	919	11.80	0.172	0.0092	0.0060	
0.365	810	11.48	0.148	0.0090	0.0058	
0.365	688	11.48	0.126	0.0090	0.0058	
0.375	510	11.80	0.096	0.0092	0.0060	
0.425	269	13.38	0.057	0.0105	0.0068	
0.475	170	14.92	0.046	0.0117	0.0076	

Remarks:—

B E A R I N G A

Table No. 5 Date July 2nd, 1915.

Bearing Load, LBS. 900 Time, beginning of run 9:45 A.M.

Room Temp.° Fahr. 75 Time, end of run 10:10 A.M.

Observers _____

NOTE:—All data average of four bearings.

POUNDS at 31½ in. radius	R. P. M.	TORQUE		Horse Power to Drive	COEFFICIENT OF FRICTION	
		Inch	Lbs.		Shaft	Bearing
0.435	2065	13.70		0.453	0.0125	0.0081
0.39	1826	12.28		0.356	0.0112	0.0073
0.34	1687	10.70		0.287	0.0098	0.0064
0.33	1469	10.40		0.242	0.0095	0.0062
0.325	1279	10.23		0.208	0.0094	0.0061
0.32	948	10.08		0.152	0.0092	0.0060
0.32	841	10.08		0.135	0.0092	0.0060
0.315	715	9.93		0.113	0.0091	0.0059
0.32	490	10.08		0.079	0.0092	0.0060
0.37	242	10.64		0.045	0.0097	0.0063
0.40	166	12.60		0.033	0.0115	0.0075

Remarks:—

B E A R I N G A

Table No. 6 Date July 2nd, 1915.

Bearing Load, LBS. 750 Time, beginning of run 10:10 A.M.

Room Temp.° Fahr. 75 Time, end of run 10:30 A.M.

Observers _____

NOTE:—All data average of four bearings.

POUNDS at 31½ in. radius	R. P. M.	TORQUE Inch Lbs.	Horse Power to Drive	COEFFICIENT OF FRICTION	
				Shaft	Bearing
0.35	2205	11.02	0.386	0.0121	0.0079
0.325	2072	10.23	0.336	0.0112	0.0073
0.30	1834	9.46	0.275	0.0104	0.0067
0.28	1481	8.82	0.208	0.0097	0.0063
0.28	1308	8.82	0.183	0.0097	0.0063
0.27	1096	8.51	0.148	0.0093	0.0060
0.27	914	8.51	0.123	0.0093	0.0060
0.27	827	8.51	0.112	0.0093	0.0060
0.27	760	8.51	0.103	0.0093	0.0060
0.27	560	8.51	0.076	0.0093	0.0060
0.28	334	8.82	0.047	0.0097	0.0063
0.33	202	10.40	0.033	0.0114	0.0074

Remarks:—

B E A R I N G A

Table No. 7 Date July 2nd, 1915.

Bearing Load, LBS. 600 Time, beginning of run 10:30 A.M.

Room Temp.° Fahr. 75 Time, end of run 10:45 A.M.

Observers _____

NOTE:—All data average of four bearings.

POUNDS at 31½ in. radius	R. P. M.	TORQUE		Horse Power to Drive	COEFFICIENT OF FRICTION	
		Inch	Lbs.		Shaft	Bearing
0.33	2316	10.40	0.382	0.0142	0.0092	
0.31	1944	9.78	0.302	0.0134	0.0087	
0.28	1626	8.82	0.228	0.0121	0.0078	
0.26	1329	8.19	0.173	0.0112	0.0073	
0.25	1077	7.88	0.135	0.0108	0.0070	
0.23	972	7.25	0.112	0.0099	0.0064	
0.21	856	6.61	0.090	0.0091	0.0059	
0.20	653	6.30	0.065	0.0086	0.0056	
0.255	221	8.04	0.028	0.0110	0.0071	
0.275	148	8.67	0.020	0.0119	0.0077	

Remarks:—

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8	9	10	11	12
13	14	15	16	17
18	19	20	21	22
23	24	25	26	27
28	29	30	31	32
33	34	35	36	37
38	39	40	41	42
43	44	45	46	47
48	49	50	51	52
53	54	55	56	57
58	59	60	61	62
63	64	65	66	67
68	69	70	71	72
73	74	75	76	77
78	79	80	81	82
83	84	85	86	87
88	89	90	91	92
93	94	95	96	97
98	99	100	101	102

B E A R I N G A

Table No. 8 Date July 2nd, 1915.

Bearing Load, LBS. 450 Time, beginning of run 10:45 A.M.

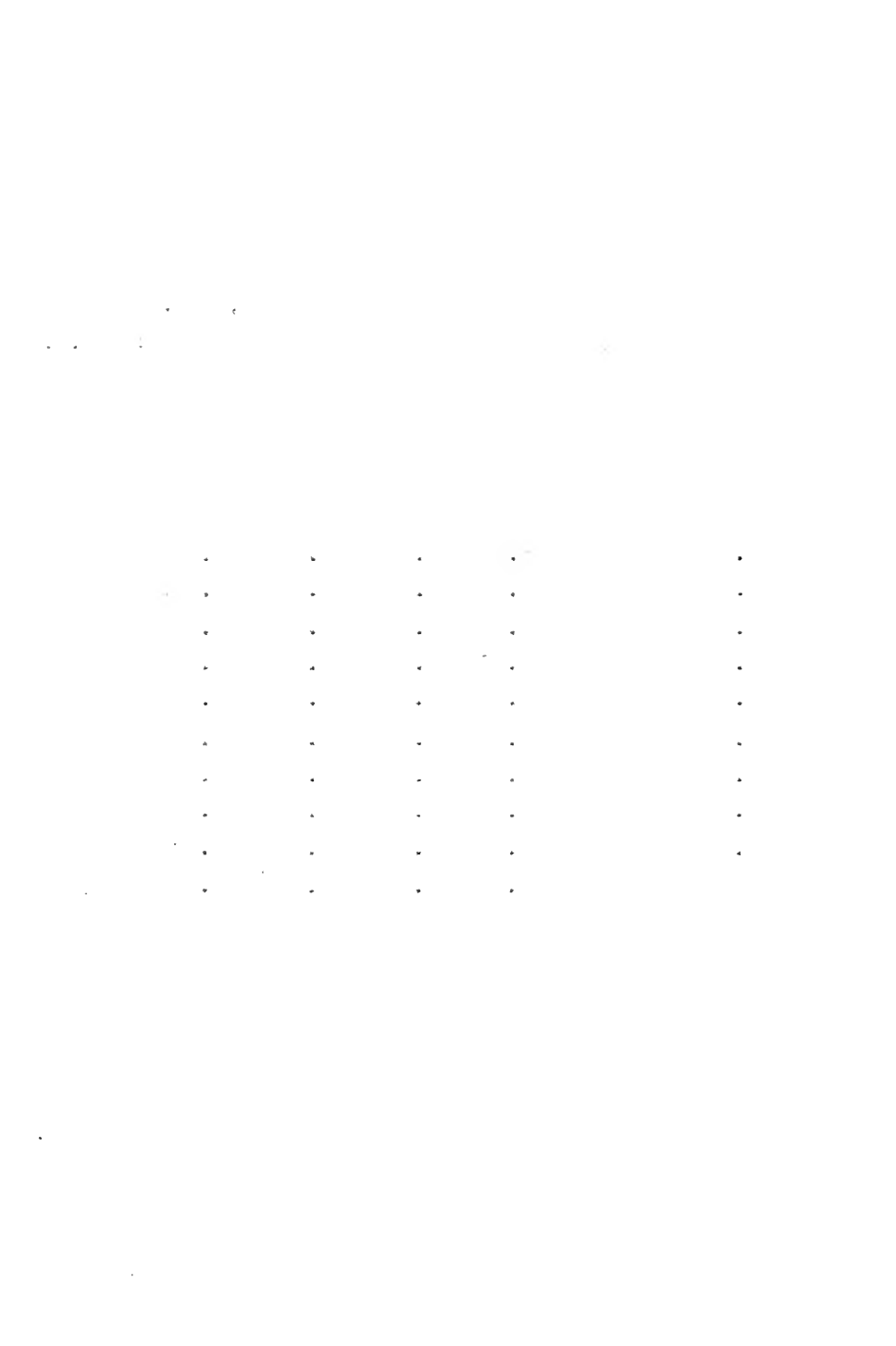
Room Temp.° Fahr. 75 Time, end of run _____

Observers _____

NOTE:—All data average of four bearings.

POUNDS at 31½ in. radius	R. P. M.	TORQUE		Horse Power to Drive	COEFFICIENT OF FRICTION	
		Inch	Lbs.		Shaft	Bearing
0.29	2349	9.14	0.342	0.0167	0.0108	
0.25	1986	7.88	0.248	0.0144	0.0093	
0.23	1736	7.25	0.200	0.0132	0.0086	
0.215	1439	6.78	0.155	0.0124	0.0080	
0.20	1112	6.30	0.111	0.0115	0.0075	
0.19	970	5.99	0.092	0.0109	0.0071	
0.19	800	5.99	0.076	0.0109	0.0071	
0.185	603	5.83	0.056	0.0106	0.0069	
0.195	384	6.15	0.037	0.0112	0.0073	
	206	10.08	0.033	0.0184	0.0119	

Remarks:—



B E A R I N G A

Table No. 9 Date July 2nd, 1915.

Bearing Load, LBS. 300 Time, beginning of run _____

Room Temp.° Fahr. 75 Time, end of run 11:15 A.M.

Observers _____

NOTE:—All data average of four bearings.

POUNDS at 31½ in. radius	R. P. M.	TORQUE		Horse Power to Drive	COEFFICIENT OF FRICTION	
		Inch	Lbs.		Shaft	Bearing
0.22	2577	6.93	0.283	0.0189	0.0123	
0.185	2174	5.83	0.201	0.0159	0.0103	
0.165	1743	5.20	0.144	0.0142	0.0092	
0.135	1388	4.25	0.094	0.0116	0.0075	
0.105	988	3.31	0.052	0.0091	0.0059	
0.09	886	2.83	0.040	0.0078	0.0051	
0.085	818	2.68	0.035	0.0073	0.0047	
0.08	591	2.52	0.024	0.0069	0.0045	
0.105	235	3.31	0.012	0.0091	0.0059	
0.13	139	4.09	0.009	0.0112	0.0073	

Remarks:—

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DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ A _____

R. P. M. of Shaft _____ 2000 _____

Table No. 10 _____

Bearing Load	Horse Power to Drive	COEFFICIENT OF FRICTION	
		Shaft	Bearing
1500			
1350			
1200			
1050			
900	0.400	0.012	0.0080
750	0.315	0.0115	0.0075
600	0.315	0.0130	0.0085
450	0.255	0.0150	0.0097
300	0.175	0.0150	0.0097

Remarks:—

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DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ A _____

R. P. M. of Shaft _____ 1600 _____

Table No. 11 _____

Bearing Load	Horse Power to Drive	COEFFICIENT OF FRICTION	
		Shaft	Bearing
1500	0.435	0.0095	0.0062
1350	0.390	0.0092	0.0060
1200	0.345	0.0095	0.0060
1050	0.316	0.0097	0.0062
900	0.265	0.010	0.0068
750	0.230	0.0105	0.0065
600	0.230	0.015	0.0075
450	0.180	0.0134	0.0085
300	0.125	0.0125	0.0080

Remarks:—

DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ **A** _____

R. P. M. of Shaft _____ **1200** _____

Table No. **12** _____

Bearing Load	Horse Power to Drive	COEFFICIENT OF FRICTION	
		Shaft	Bearing
1500	0.315	0.0088	0.0055
1350	0.280	0.0090	0.0058
1200	0.245	0.0090	0.0058
1050	0.225	0.0095	0.0060
900	0.190	0.0093	0.0058
750	0.162	0.0096	0.0060
600	0.151	0.0098	0.0065
450	0.120	0.012	0.0070
300	0.070	0.0097	0.0060

Remarks:—

DATA INTERPOLATED
FROM TABLES 1-9

Bearing ————— A —————

R. P. M. of Shaft — 800 —

Table No. 13 —————

Bearing Load	Horse Power to Drive	COEFFICIENT OF FRICTION	
		Shaft	Bearing
1500	0.21	0.0088	0.0055
1350	0.190	0.0095	0.0060
1200	0.165	0.0085	0.0055
1050	0.152	0.0092	0.0060
900	0.128	0.0090	0.0055
750	0.110	0.0092	0.0058
600	0.090	0.009	0.0059
450	0.075	0.0105	0.0065
300	0.038	0.0075	0.005

Remarks:—

DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ A _____

R. P. M. of Shaft _____ 600 _____

Table No. 14 _____

Bearing Load	Horse Power to Drive	COEFFICIENT OF FRICTION	
		Shaft	Bearing
1500	0.164	0.009	0.0064
1350	0.150	0.010	0.0068
1200	0.125	0.009	0.0055
1050	0.115	0.009	0.0060
900	0.10	0.009	0.0055
750	0.085	0.0092	0.0060
600	0.065	0.0090	0.0058
450	0.056	0.0107	0.0065
300	0.025	0.0071	0.0048

Remarks:—

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DATA INTERPOLATED
FROM TABLES 1—9

Bearing A

R. P. M. of Shaft 400

Table No. 15

Bearing Load	Horse Power to Drive	COEFFICIENT OF FRICTION	
		Shaft	Bearing
1500	0.115	0.0095	0.0063
1350	0.105	0.010	0.0068
1200	0.085	0.0098	0.0064
1050	0.080	0.0096	0.0063
900	0.068	0.0095	0.0060
750	0.057	0.0098	0.0063
600	0.045	0.0098	0.0060
450	0.042	0.013	0.0078
300	0.015	0.0077	0.0052

Remarks:—

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DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ A _____

R. P. M. of Shaft _____ 200 _____

Table No. 16 _____

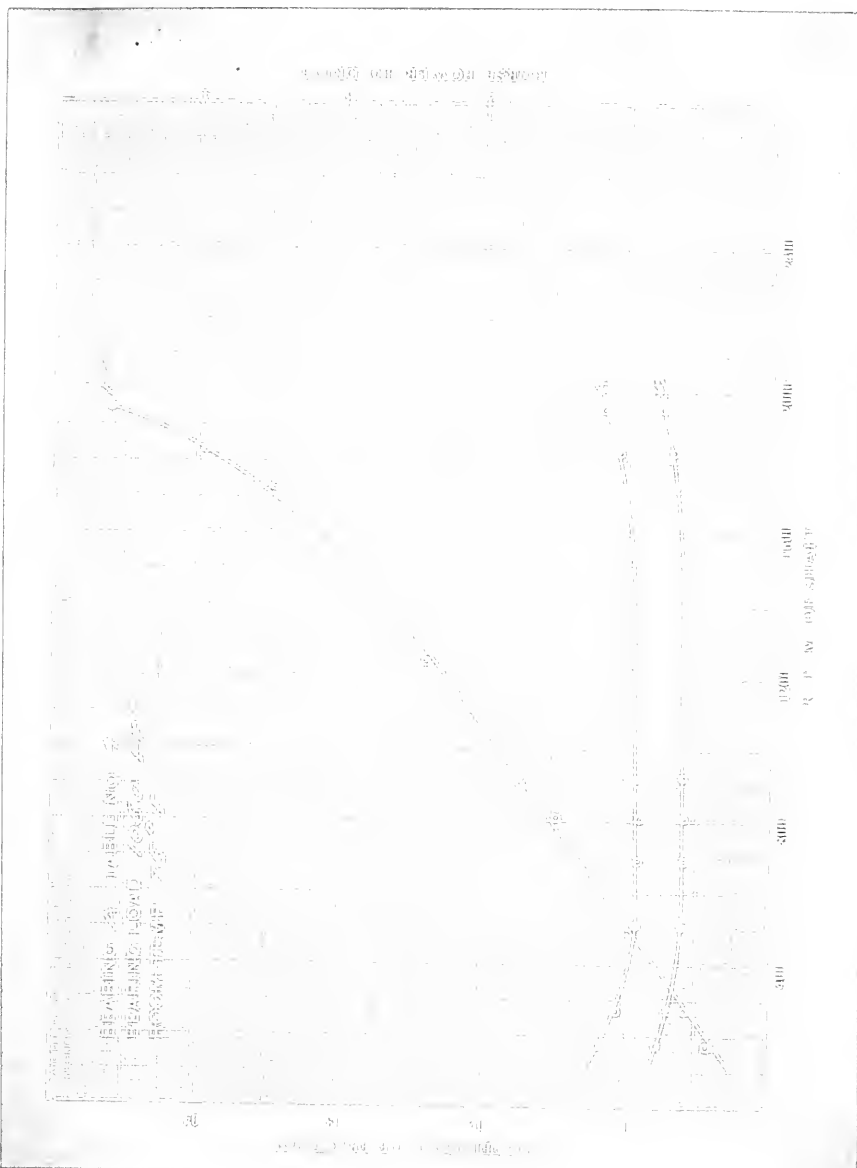
Bearing Load	Horse Power to Drive	COEFFICIENT OF FRICTION	
		Shaft	Bearing
1500	0.063	0.01	0.007
1350	0.062	0.011	0.0075
1200	0.045	0.011	0.0075
1050	0.042	0.0115	0.0075
900	0.038	0.0110	0.0073
750	0.035	0.0114	0.0075
600	0.025	0.0113	0.0070
450	0.032	0.0185	0.012
300	0.010	0.010	0.0065

Remarks:—

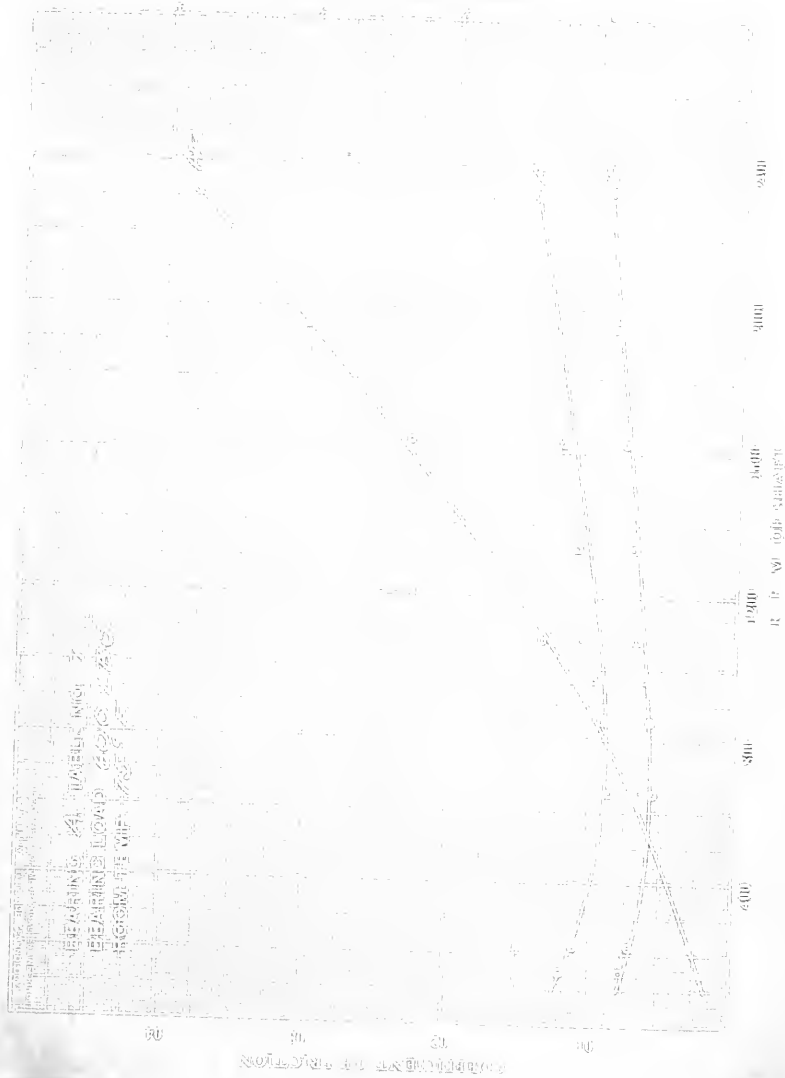
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CURVES PLOTTED FROM
TABLES 1 - 16
OF
BEARING "A"





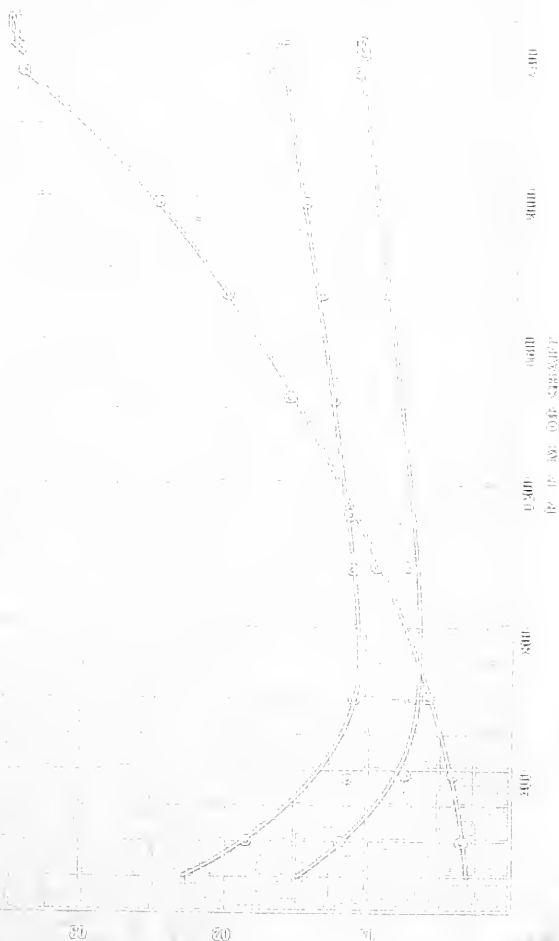
WATER LEVELS FROM 1910 TO 1915





BEARING 4 HAWKING (S)
 BEARING 1000 7100 (S)
 BEARING 1000 7100 (S)

COEFFICIENT OF FRICTION



COEFFICIENT OF FRICTION



1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100.



TEMPERATURE OF AIR

READING A TABLE NO. 10
 IN H.M. OF SHIP'S LOG

1000

20

NUMBER OF DEGREES

300

400

500

600

700

800

900

TEMPERATURE OF AIR

Figure 1. The effect of the concentration of the solution on the rate of the reaction.

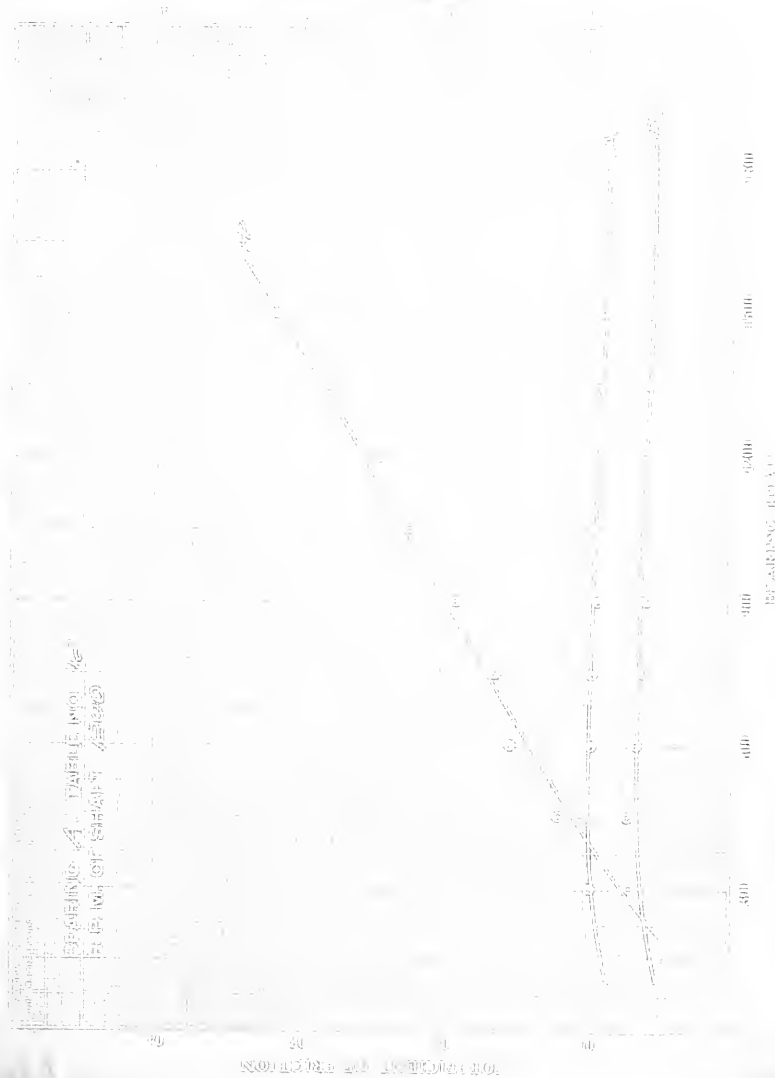
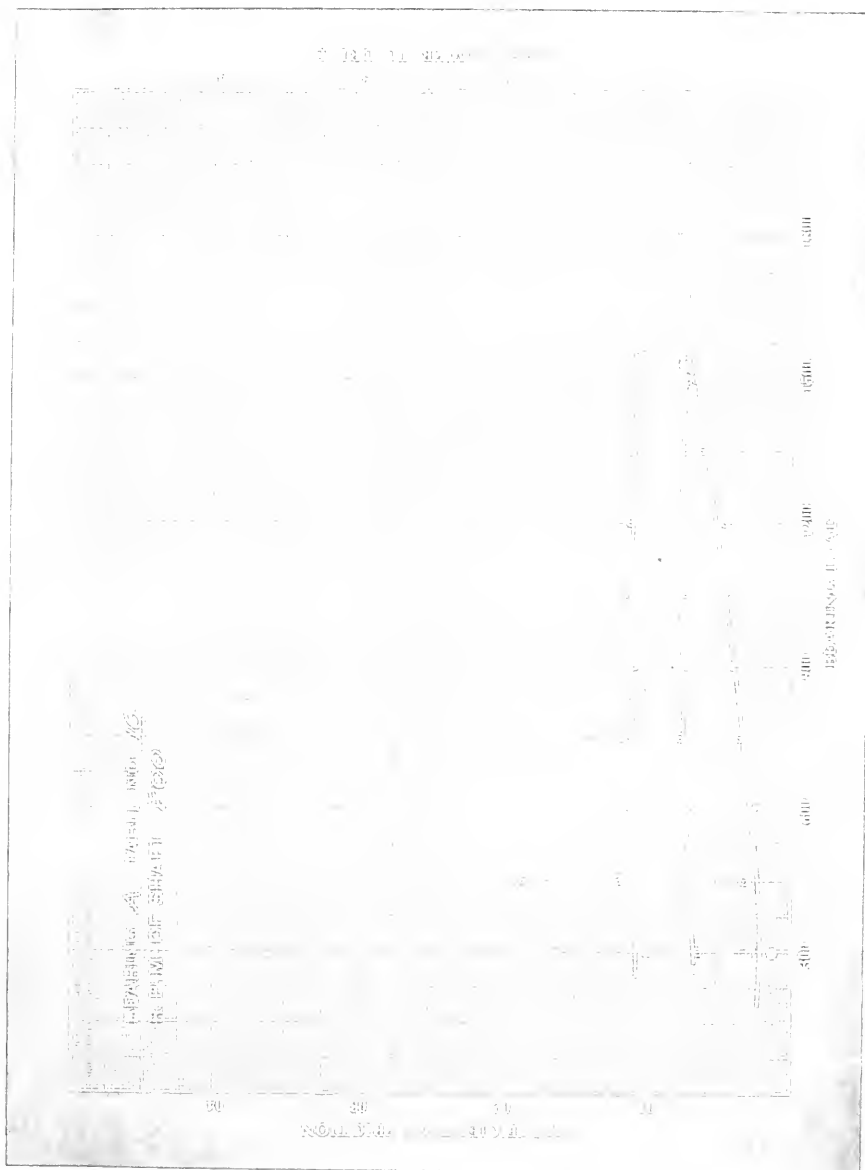


Figure 10.10.1. Section 40.41. 45.5.0.0.0.





BEARING "B"

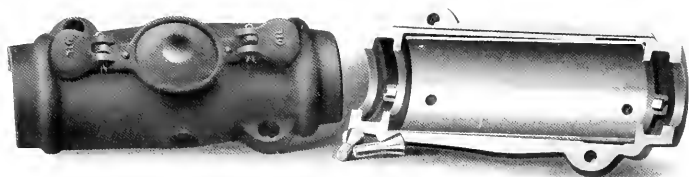


Fig. 6

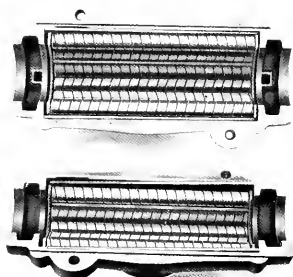


Fig. 7



Fig. 8

BEARING "B"

Bearing "B", (Figures 6,7,8), has as its distinctive feature, a flexible roller which is made from a strip of steel wound into a helical coil or spring of uniform diameter. There are eleven of the coiled rolls in each bearing, six of them coiled in the right hand direction and five in the left hand direction. (Fig.7) The rolls are held in a separator and they run directly on the shaft.

The box is of iron, cast in two parts and lined with steel; the steel serving the purpose of an outer raceway for the rolls. (Fig.6)

The greatest advantage of a roller of this construction is, that it is flexible, which enables it to present a bearing surface along its entire length resulting in a uniform distribution of the load. The roller adjusts itself to any irregularity in the rubbing surface. The roller being hollow acts as an



oil reservoir, thereby, assuring good lubrication at all times.

These bearings could not be run over seven hundred revolutions, it being the claim of the firm manufacturing this bearing that it is built only for ordinary line shaft purposes; in other words, at speeds of 300 to 400 R.P.M.

At such speeds these bearings showed a tendency to heat up, but, not to any great extent on the lighter loads.

These rollers can be made longer than a solid roller, because, they are flexible, whereas, a solid roll does not bend to the deflection of the shaft. But, there is a disadvantage to this roller just as there is to the solid ones. It requires power to flex a spring, therefore, the constant working of these resilient rolls to allow for irregularities of alignment and surface must absorb an appreciable amount of power which is dissipated as heat.



TABLES 1 - 13

OF

BEARING "B"

B E A R I N G B

Table No. 1 Date July 6th, 1915.

Bearing Load, LBS. 1500 Time, beginning of run 10:06 A.M.

Room Temp.° Fahr. 72 Time, end of run 10:30 A.M.

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE
Inch Lbs. | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|---------------------|-------------------------|-------------------------|---------|
| | | | | Shaft | Bearing |
| 0.68 | 745 | 21.40 | 0.253 | 0.0117 | 0.0089 |
| 0.65 | 653 | 20.48 | 0.212 | 0.0112 | 0.0085 |
| 0.62 | 632 | 19.52 | 0.196 | 0.0107 | 0.0081 |
| 0.595 | 617 | 18.72 | 0.184 | 0.0103 | 0.0078 |
| 0.58 | 603 | 18.26 | 0.175 | 0.0100 | 0.0076 |
| 0.54 | 559 | 17.00 | 0.151 | 0.0093 | 0.0071 |
| 0.525 | 456 | 16.51 | 0.120 | 0.0091 | 0.0069 |
| 0.495 | 443 | 15.58 | 0.110 | 0.0085 | 0.0064 |
| 0.45 | 390 | 14.16 | 0.088 | 0.0078 | 0.0059 |
| 0.42 | 328 | 13.23 | 0.069 | 0.0073 | 0.0055 |
| 0.39 | 283 | 12.28 | 0.055 | 0.0061 | 0.0051 |
| 0.305 | 224 | 11.50 | 0.041 | 0.0063 | 0.0048 |
| 0.35 | 178 | 11.00 | 0.031 | 0.0060 | 0.0046 |
| | | | | | |
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Remarks:—

B E A R I N G B

Table No. 2 Date July 6th, 1915.

Bearing Load, LBS. 1350 Time, beginning of run 10:30 A.M.

Room Temp.° Fahr. 72 Time, end of run 11:10 A.M.

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE | | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|--------|-------|-------------------------|-------------------------|---------|
| | | Inch | Lbs. | | Shaft | Bearing |
| 0.585 | 729 | 18.41 | 0.213 | 0.0112 | 0.0085 | |
| 0.56 | 708 | 17.65 | 0.198 | 0.0107 | 0.0081 | |
| 0.535 | 657 | 16.85 | 0.176 | 0.0102 | 0.0077 | |
| 0.51 | 633 | 16.07 | 0.161 | 0.0098 | 0.0074 | |
| 0.49 | 599 | 15.42 | 0.147 | 0.0094 | 0.0071 | |
| 0.455 | 536 | 14.35 | 0.122 | 0.0087 | 0.0066 | |
| 0.42 | 495 | 13.22 | 0.104 | 0.0080 | 0.0061 | |
| 0.39 | 410 | 12.28 | 0.080 | 0.0075 | 0.0057 | |
| 0.365 | 373 | 11.48 | 0.068 | 0.0070 | 0.0053 | |
| 0.335 | 271 | 10.54 | 0.045 | 0.0064 | 0.0048 | |
| 0.31 | 207 | 9.76 | 0.032 | 0.0059 | 0.0045 | |
| 0.30 | 174 | 9.45 | 0.026 | 0.0057 | 0.0043 | |
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Remarks:—

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| 25 | 26 | 27 | 28 | 29 | 30 |
| 31 | 32 | 33 | 34 | 35 | 36 |
| 37 | 38 | 39 | 40 | 41 | 42 |
| 43 | 44 | 45 | 46 | 47 | 48 |
| 49 | 50 | 51 | 52 | 53 | 54 |
| 55 | 56 | 57 | 58 | 59 | 60 |
| 61 | 62 | 63 | 64 | 65 | 66 |
| 67 | 68 | 69 | 70 | 71 | 72 |

B E A R I N G B

Table No. 3 Date July 6th, 1915.

Bearing Load, LBS. 1200 Time, beginning of run 11:18 A.M.

Room Temp.° Fahr. 72 Time, end of run 11:30 A.M.

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE
Inch Lbs. | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|---------------------|-------------------------|-------------------------|---------|
| | | | | Shaft | Bearing |
| 0.555 | 771 | 17.50 | 0.214 | 0.0120 | 0.0091 |
| 0.50 | 689 | 15.75 | 0.172 | 0.0108 | 0.0082 |
| 0.48 | 662 | 15.12 | 0.159 | 0.0103 | 0.0078 |
| 0.45 | 611 | 14.18 | 0.137 | 0.0094 | 0.0071 |
| 0.395 | 510 | 12.45 | 0.101 | 0.0085 | 0.0064 |
| 0.36 | 436 | 11.34 | 0.079 | 0.0078 | 0.0059 |
| 0.305 | 262 | 9.62 | 0.040 | 0.0066 | 0.0050 |
| 0.285 | 183 | 8.97 | 0.026 | 0.0061 | 0.0046 |
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Remarks:—

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B E A R I N G B

Table No. 4 Date July 6th, 1915.

Bearing Load, LBS. 1050 Time, beginning of run 11:30 A.M.

Room Temp.° Fahr. 72 Time, end of run 11:46 A.M.

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE
Inch Lbs. | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|---------------------|-------------------------|-------------------------|---------|
| | | | | Shaft | Bearing |
| 0.495 | 758 | 15.57 | 0.188 | 0.0122 | 0.0092 |
| 0.45 | 674 | 14.18 | 0.152 | 0.0111 | 0.0084 |
| 0.425 | 628 | 13.38 | 0.133 | 0.0105 | 0.0079 |
| 0.40 | 589 | 12.58 | 0.118 | 0.0099 | 0.0075 |
| 0.37 | 524 | 11.64 | 0.097 | 0.0091 | 0.0069 |
| 0.315 | 400 | 9.92 | 0.063 | 0.0078 | 0.0059 |
| 0.28 | 285 | 8.82 | 0.040 | 0.0069 | 0.0052 |
| 0.25 | 196 | 7.87 | 0.025 | 0.0062 | 0.0047 |
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Remarks:—

BEARING B

Table No. 5 Date July 6th, 1915.

Bearing Load, LBS. 900 Time, beginning of run 11:46 A.M.

Room Temp.^o Fahr. 72 Time, end of run 11:56 A.M.

Observers _____

NOTE:—All data average of four bearings.

[illegible]

Remarks:—

B E A R I N G B

Table No. 6 Date July 6th, 1915.

Bearing Load, LBS. 750 Time, beginning of run 11:56 A.M.

Room Temp.° Fahr. 72 Time, end of run 12:10 P.M.

Observers _____

NOTE:—All data average of four bearings.

[illegible]

Remarks:—

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2 2 2
2 2 2

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B E A R I N G B

Table No. 7 Date July 6th, 1915.

Bearing Load, LBS. 600 Time, beginning of run 12:10 P.M.

Room Temp.° Fahr. 72 Time, end of run 12:30 P.M.

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE | | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|--------|------|-------------------------|-------------------------|---------|
| | | Inch | Lbs. | | Shaft | Bearing |
| 0.41 | 719 | 12.89 | | 0.147 | 0.0176 | 0.0133 |
| 0.375 | 672 | 11.79 | | 0.126 | 0.0161 | 0.0122 |
| 0.335 | 574 | 10.53 | | 0.096 | 0.0144 | 0.0109 |
| 0.30 | 493 | 9.45 | | 0.074 | 0.0129 | 0.0098 |
| 0.255 | 329 | 8.03 | | 0.042 | 0.0110 | 0.0083 |
| 0.255 | 334 | 8.03 | | 0.043 | 0.0110 | 0.0083 |
| 0.24 | 305 | 7.55 | | 0.037 | 0.0103 | 0.0078 |
| 0.225 | 274 | 7.08 | | 0.031 | 0.0097 | 0.0073 |
| 0.215 | 217 | 6.76 | | 0.023 | 0.0093 | 0.0070 |
| 0.20 | 155 | 6.29 | | 0.016 | 0.0086 | 0.0065 |
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Remarks:—

10. 11. 2019

11. 11. 2019

12. 11. 2019

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| 1 | 2 | 3 | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 |
| 11 | 12 | 13 | 14 | 15 |
| 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 |
| 31 | 32 | 33 | 34 | 35 |
| 36 | 37 | 38 | 39 | 40 |
| 41 | 42 | 43 | 44 | 45 |
| 46 | 47 | 48 | 49 | 50 |

BEARING B

Table No. 8 Date July 6th, 1915.

Bearing Load, LBS. 450 Time, beginning of run 12:30 P.M.

Room Temp.° Fahr. 72 Time, end of run 12:45 P.M.

Observers

NOTE:—All data average of four bearings.

[illegible]

Remarks:—

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B E A R I N G B

Table No. 9 Date July 6th, 1915.

Bearing Load, LBS. 300 Time, beginning of run 12:45 P.M.

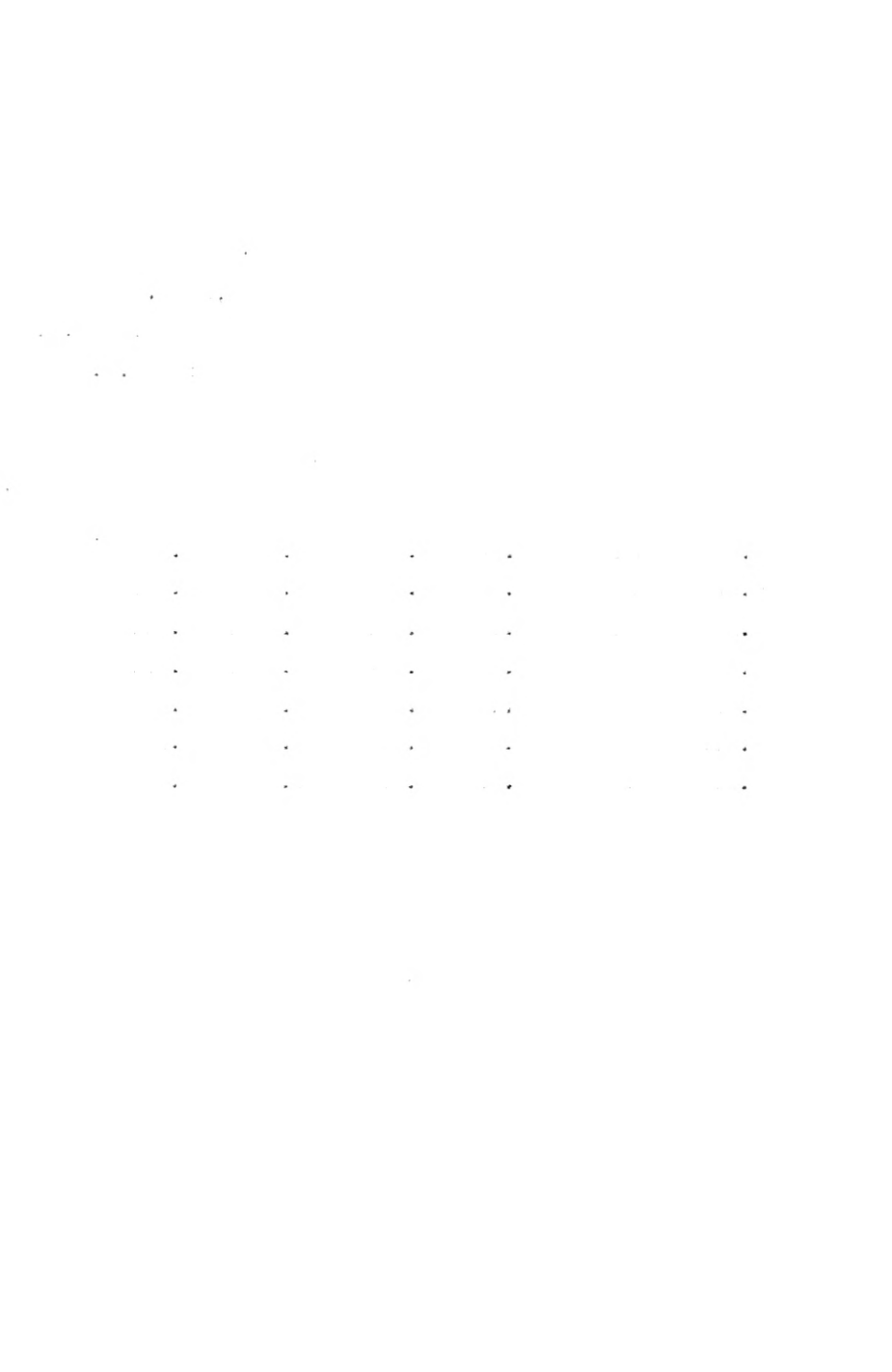
Room Temp.° Fahr. 72 Time, end of run 12:55 P.M.

Observers _____

NOTE:—All data average of four bearings.

[illegible]

Remarks:—



DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ B _____

R. P. M. of Shaft _____ 800 _____

Table No. 10 _____

| Bearing Load | Horse Power to Drive | COEFFICIENT OF FRICTION | |
|--------------|----------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | | 0.0120 | 0.0097 |
| 1350 | | 0.0120 | 0.0097 |
| 1200 | 0.23 | 0.0120 | 0.0095 |
| 1050 | 0.223 | 0.0130 | 0.0098 |
| 900 | 0.210 | 0.0147 | 0.0115 |
| 750 | 0.195 | 0.0160 | 0.0125 |
| 600 | 0.195 | 0.0135 | 0.0140 |
| 450 | 0.185 | 0.025 | 0.0193 |
| 300 | 0.160 | 0.036 | 0.026 |
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Remarks:—

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DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ B _____

R. P. M. of Shaft _____ 600 _____

Table No. 11 _____

| Bearing Load | Horse Power to Drive | COEFFICIENT OF FRICTION | |
|--------------|----------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.170 | 0.0100 | 0.0077 |
| 1350 | 0.14 | 0.0092 | 0.0072 |
| 1200 | 0.135 | 0.0092 | 0.0070 |
| 1050 | 0.120 | 0.010 | 0.0075 |
| 900 | 0.1150 | 0.0115 | 0.0085 |
| 750 | 0.110 | 0.0123 | 0.0095 |
| 600 | 0.105 | 0.0148 | 0.011 |
| 450 | 0.100 | 0.0190 | 0.0142 |
| 300 | 0.092 | 0.0262 | 0.020 |
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Remarks:—

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| 1 | 2 | 3 |
| 4 | 5 | 6 |
| 7 | 8 | 9 |
| 10 | 11 | 12 |
| 13 | 14 | 15 |
| 16 | 17 | 18 |
| 19 | 20 | 21 |
| 22 | 23 | 24 |
| 25 | 26 | 27 |
| 28 | 29 | 30 |
| 31 | 32 | 33 |

DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ B _____

R. P. M. of Shaft _____ 400 _____

Table No. 12 _____

| Bearing
Load | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------|-------------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.09 | 0.008 | 0.006 |
| 1350 | 0.065 | 0.0073 | 0.0055 |
| 1200 | 0.070 | 0.0075 | 0.0054 |
| 1050 | 0.063 | 0.0080 | 0.0055 |
| 900 | 0.057 | 0.0090 | 0.0065 |
| 750 | 0.055 | 0.0095 | 0.0075 |
| 600 | 0.052 | 0.0115 | 0.0065 |
| 450 | 0.048 | 0.0145 | 0.0108 |
| 300 | 0.045 | 0.020 | 0.0150 |
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Remarks:—

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| 4 | 5 | 6 |
| 7 | 8 | 9 |
| 10 | 11 | 12 |
| 13 | 14 | 15 |
| 16 | 17 | 18 |
| 19 | 20 | 21 |
| 22 | 23 | 24 |
| 25 | 26 | 27 |
| 28 | 29 | 30 |
| 31 | 32 | 33 |
| 34 | 35 | 36 |
| 37 | 38 | 39 |
| 40 | 41 | 42 |
| 43 | 44 | 45 |
| 46 | 47 | 48 |
| 49 | 50 | 51 |
| 52 | 53 | 54 |
| 55 | 56 | 57 |
| 58 | 59 | 60 |
| 61 | 62 | 63 |
| 64 | 65 | 66 |
| 67 | 68 | 69 |
| 70 | 71 | 72 |
| 73 | 74 | 75 |
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| 79 | 80 | 81 |
| 82 | 83 | 84 |
| 85 | 86 | 87 |
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| 142 | 143 | 144 |
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| 148 | 149 | 150 |
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| 154 | 155 | 156 |
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| 163 | 164 | 165 |
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| 175 | 176 | 177 |
| 178 | 179 | 180 |
| 181 | 182 | 183 |
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| 193 | 194 | 195 |
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| 205 | 206 | 207 |
| 208 | 209 | 210 |
| 211 | 212 | 213 |
| 214 | 215 | 216 |
| 217 | 218 | 219 |
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| 232 | 233 | 234 |
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| 238 | 239 | 240 |
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| 244 | 245 | 246 |
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| 250 | 251 | 252 |
| 253 | 254 | 255 |
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| 259 | 260 | 261 |
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| 301 | 302 | 303 |
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| 307 | 308 | 309 |
| 310 | 311 | 312 |
| 313 | 314 | 315 |
| 316 | 317 | 318 |
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| 322 | 323 | 324 |
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| 337 | 338 | 339 |
| 340 | 341 | 342 |
| 343 | 344 | 345 |
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| 352 | 353 | 354 |
| 355 | 356 | 357 |
| 358 | 359 | 360 |
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| 370 | 371 | 372 |
| 373 | 374 | 375 |
| 376 | 377 | 378 |
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| 406 | 407 | 408 |
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| 412 | 413 | 414 |
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| 433 | 434 | 435 |
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| 490 | 491 | 492 |
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| 529 | 530 | 531 |
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| 535 | 536 | 537 |
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| 541 | 542 | 543 |
| 544 | 545 | 546 |
| 547 | 548 | 549 |
| 550 | 551 | 552 |
| 553 | 554 | 555 |
| 556 | 557 | 558 |
| 559 | 560 | 561 |
| 562 | 563 | 564 |
| 565 | 566 | 567 |
| 568 | 569 | 570 |
| 571 | 572 | 573 |
| 574 | 575 | 576 |
| 577 | 578 | 579 |
| 580 | 581 | 582 |
| 583 | 584 | 585 |
| 586 | 587 | 588 |
| 589 | 590 | 591 |
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| 595 | 596 | 597 |
| 598 | 599 | 600 |
| 601 | 602 | 603 |
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| 634 | 635 | 636 |
| 637 | 638 | 639 |
| 640 | 641 | 642 |
| 643 | 644 | 645 |
| 646 | 647 | 648 |
| 649 | 650 | 651 |
| 652 | 653 | 654 |
| 655 | 656 | 657 |
| 658 | 659 | 660 |
| 661 | 662 | 663 |
| 664 | 665 | 666 |
| 667 | 668 | 669 |
| 670 | 671 | 672 |
| 673 | 674 | 675 |
| 676 | 677 | 678 |
| 679 | 680 | 681 |
| 682 | 683 | 684 |
| 685 | 686 | 687 |
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| 691 | 692 | 693 |
| 694 | 695 | 696 |
| 697 | 698 | 699 |
| 700 | 701 | 702 |
| 703 | 704 | 705 |
| 706 | 707 | 708 |
| 709 | 710 | 711 |
| 712 | 713 | 714 |
| 715 | 716 | 717 |
| 718 | 719 | 720 |
| 721 | 722 | 723 |
| 724 | 725 | 726 |
| 727 | 728 | 729 |
| 730 | 731 | 732 |
| 733 | 734 | 735 |
| 736 | 737 | 738 |
| 739 | 740 | 741 |
| 742 | 743 | 744 |
| 745 | 746 | 747 |
| 748 | 749 | 750 |
| 751 | 752 | 753 |
| 754 | 755 | 756 |
| 757 | 758 | 759 |
| 760 | 761 | 762 |
| 763 | 764 | 765 |
| 766 | 767 | 768 |
| 769 | 770 | 771 |
| 772 | 773 | 774 |
| 775 | 776 | 777 |
| 778 | 779 | 780 |
| 781 | 782 | 783 |
| 784 | 785 | 786 |
| 787 | 788 | 789 |
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| 793 | 794 | 795 |
| 796 | 797 | 798 |
| 799 | 800 | 801 |
| 802 | 803 | 804 |
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| 820 | 821 | 822 |
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| 841 | 842 | 843 |
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| 847 | 848 | 849 |
| 850 | 851 | 852 |
| 853 | 854 | 855 |
| 856 | 857 | 858 |
| 859 | 860 | 861 |
| 862 | 863 | 864 |
| 865 | 866 | 867 |
| 868 | 869 | 870 |
| 871 | 872 | 873 |
| 874 | 875 | 876 |
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| 880 | 881 | 882 |
| 883 | 884 | 885 |
| 886 | 887 | 888 |
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| 895 | 896 | 897 |
| 898 | 899 | 900 |
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| 910 | 911 | 912 |
| 913 | 914 | 915 |
| 916 | 917 | 918 |
| 919 | 920 | 921 |
| 922 | 923 | 924 |
| 925 | 926 | 927 |
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| 934 | 935 | 936 |
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| 940 | 941 | 942 |
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| 955 | 956 | 957 |
| 958 | 959 | 960 |
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| 970 | 971 | 972 |
| 973 | 974 | 975 |
| 976 | 977 | 978 |
| 979 | 980 | 981 |
| 982 | 983 | 984 |
| 985 | 986 | 987 |
| 988 | 989 | 990 |
| 991 | 992 | 993 |
| 994 | 995 | 996 |
| 997 | 998 | 999 |
| 1000 | 1001 | 1002 |
| 1003 | 1004 | 1005 |
| 1006 | 1007 | 1008 |
| 1009 | 1010 | 1011 |
| 1012 | 1013 | 1014 |
| 1015 | 1016 | 1017 |
| 1018 | 1019 | 1020 |
| 1021 | 1022 | 1023 |
| 1024 | 1025 | 1026 |
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| 1036 | 1037 | 1038 |
| 1039 | 1040 | 1041 |
| 1042 | 1043 | 1044 |
| 1045 | 1046 | 1047 |
| 1048 | 1049 | 1050 |
| 1051 | 1052 | 1053 |
| 1054 | 1055 | 1056 |
| 1057 | 1058 | 1059 |
| 1060 | 1061 | 1062 |
| 1063 | 1064 | 1065 |
| 1066 | 1067 | 1068 |
| 1069 | 1070 | 1071 |
| 1072 | 1073 | 1074 |
| 1075 | 1076 | 1077 |
| 1078 | 1079 | 1080 |
| 1081 | 1082 | 1083 |
| 1084 | 1085 | 1086 |
| 1087 | 1088 | 1089 |
| 1090 | 1091 | 10 |

DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ B _____

R. P. M. of Shaft _____ 200 _____

Table No. 13 _____

| Bearing
Load | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------|-------------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.042 | 0.0068 | 0.0050 |
| 1350 | 0.025 | 0.0060 | 0.0045 |
| 1200 | 0.032 | 0.0063 | 0.0045 |
| 1050 | 0.028 | 0.0065 | 0.0045 |
| 900 | 0.023 | 0.0075 | 0.0052 |
| 750 | 0.023 | 0.0080 | 0.0060 |
| 600 | 0.022 | 0.0095 | 0.0068 |
| 450 | 0.020 | 0.0117 | 0.0086 |
| 300 | 0.020 | 0.016 | 0.0120 |
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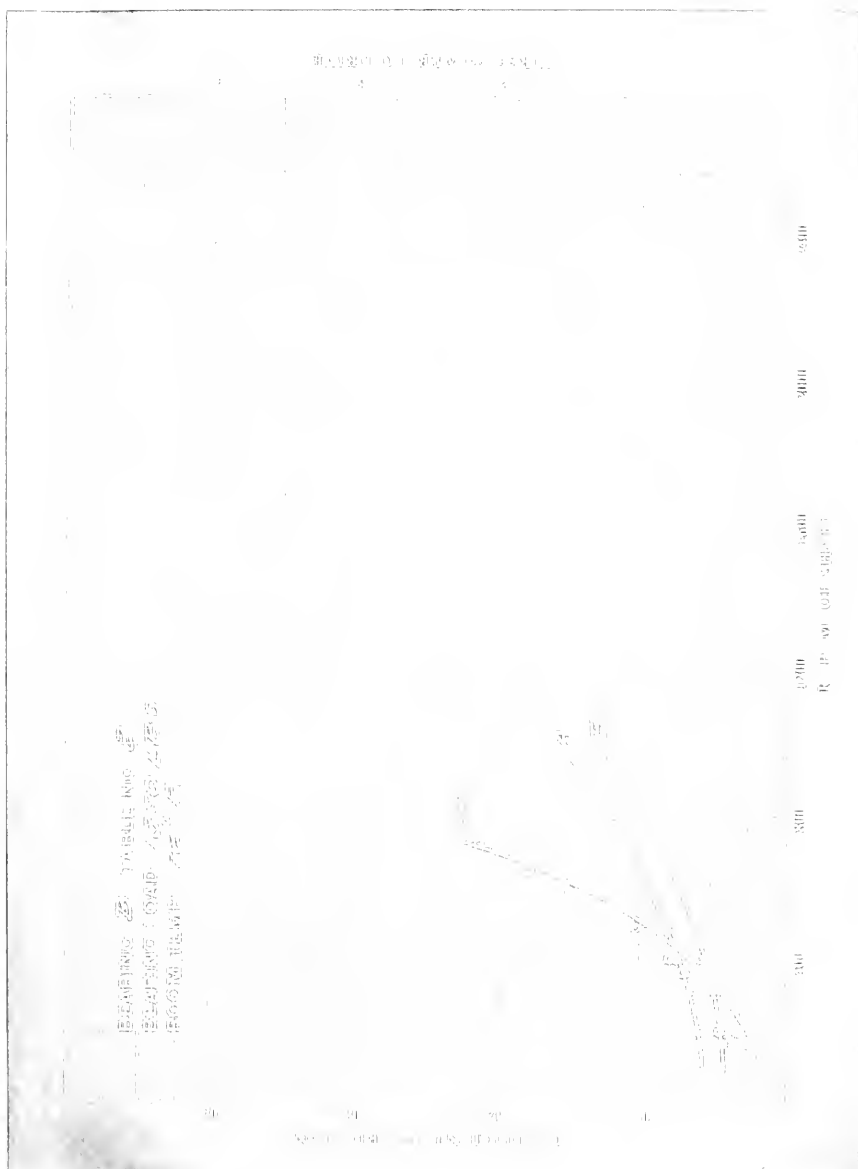
Remarks:—

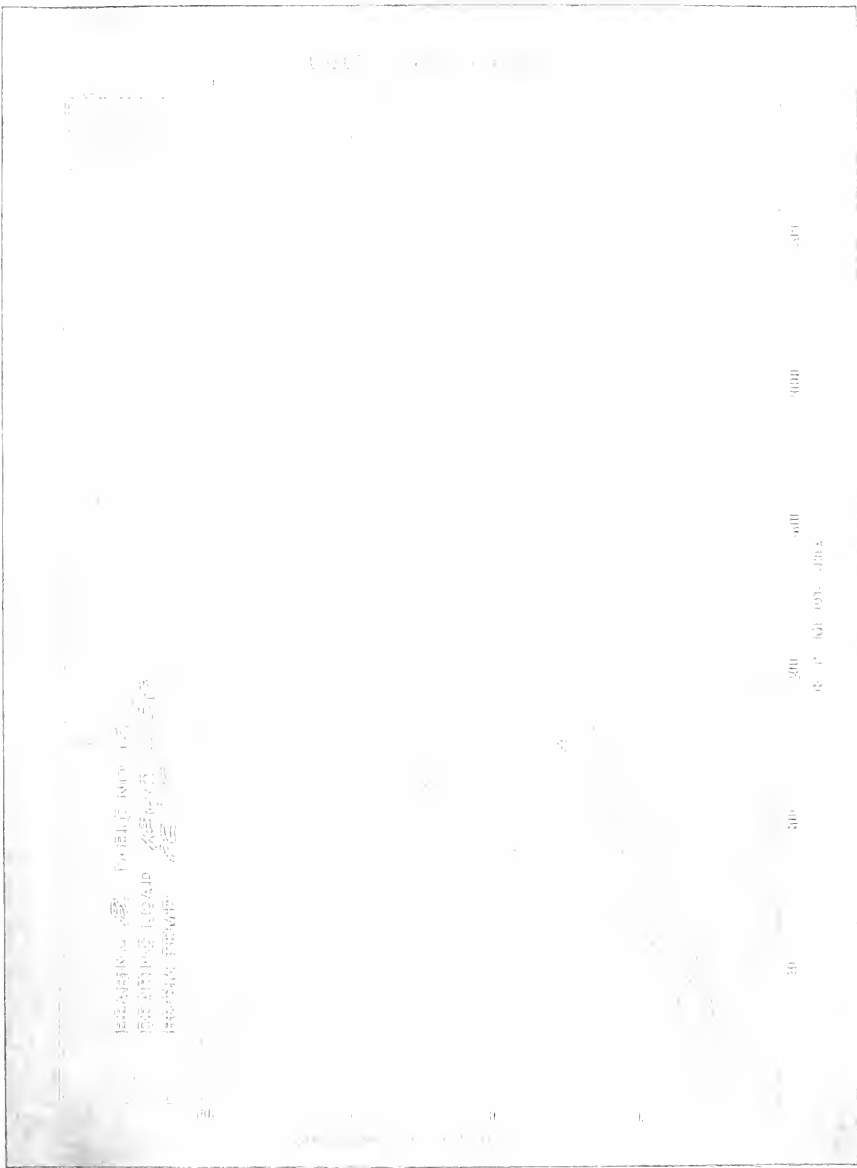
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| 31 | 32 | 33 |
| 34 | 35 | 36 |
| 37 | 38 | 39 |
| 40 | 41 | 42 |
| 43 | 44 | 45 |
| 46 | 47 | 48 |
| 49 | 50 | 51 |
| 52 | 53 | 54 |
| 55 | 56 | 57 |
| 58 | 59 | 60 |
| 61 | 62 | 63 |
| 64 | 65 | 66 |
| 67 | 68 | 69 |
| 70 | 71 | 72 |
| 73 | 74 | 75 |
| 76 | 77 | 78 |
| 79 | 80 | 81 |
| 82 | 83 | 84 |
| 85 | 86 | 87 |
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| 91 | 92 | 93 |
| 94 | 95 | 96 |
| 97 | 98 | 99 |
| 100 | 101 | 102 |

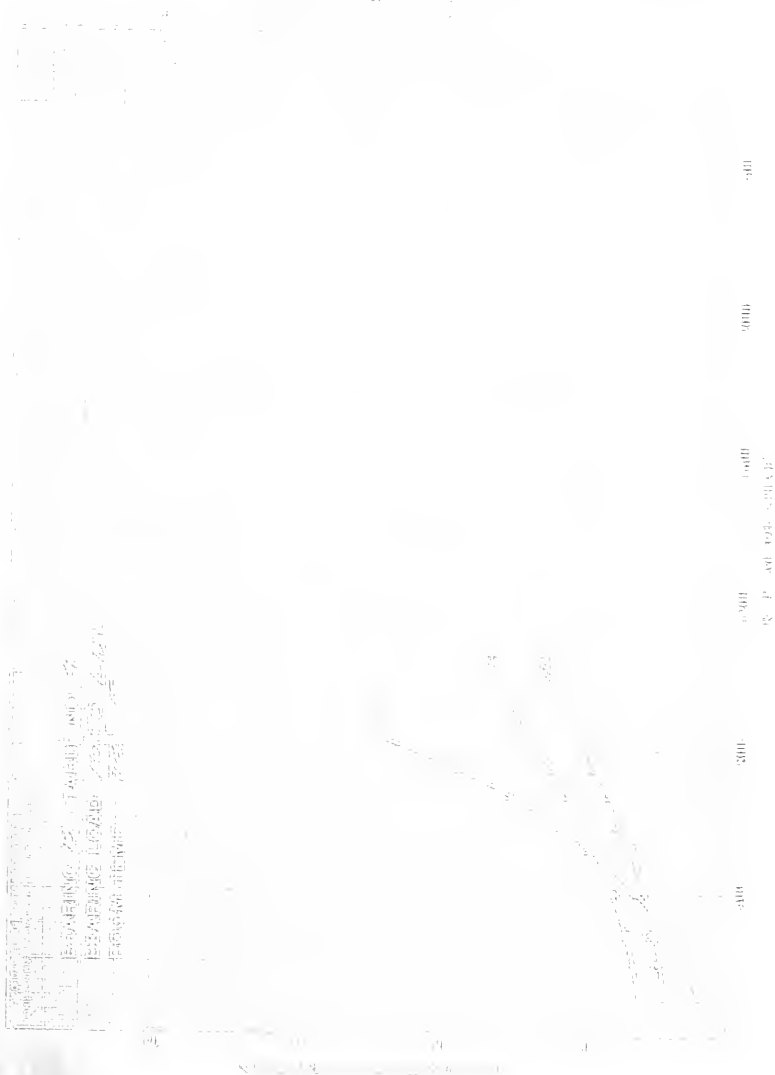
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CURVES PLOTTED FROM
TABLES 1 - 13
OF
BEARING "B"

- - - - -







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图 11 500 米等深线水深变化图

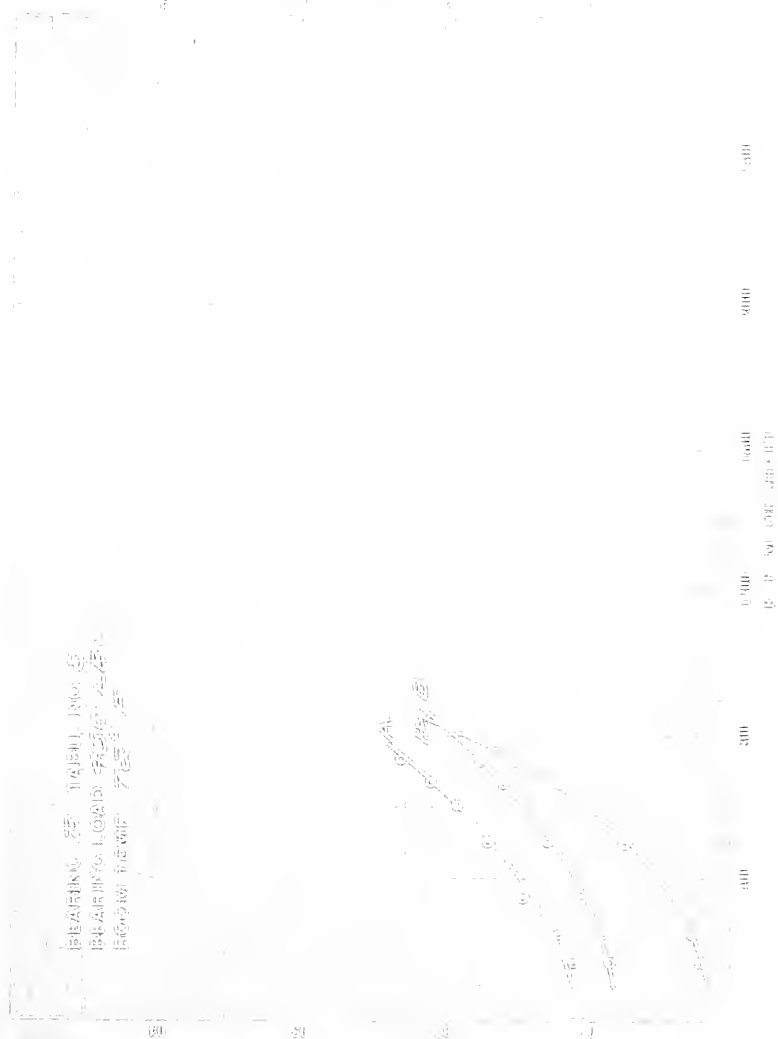
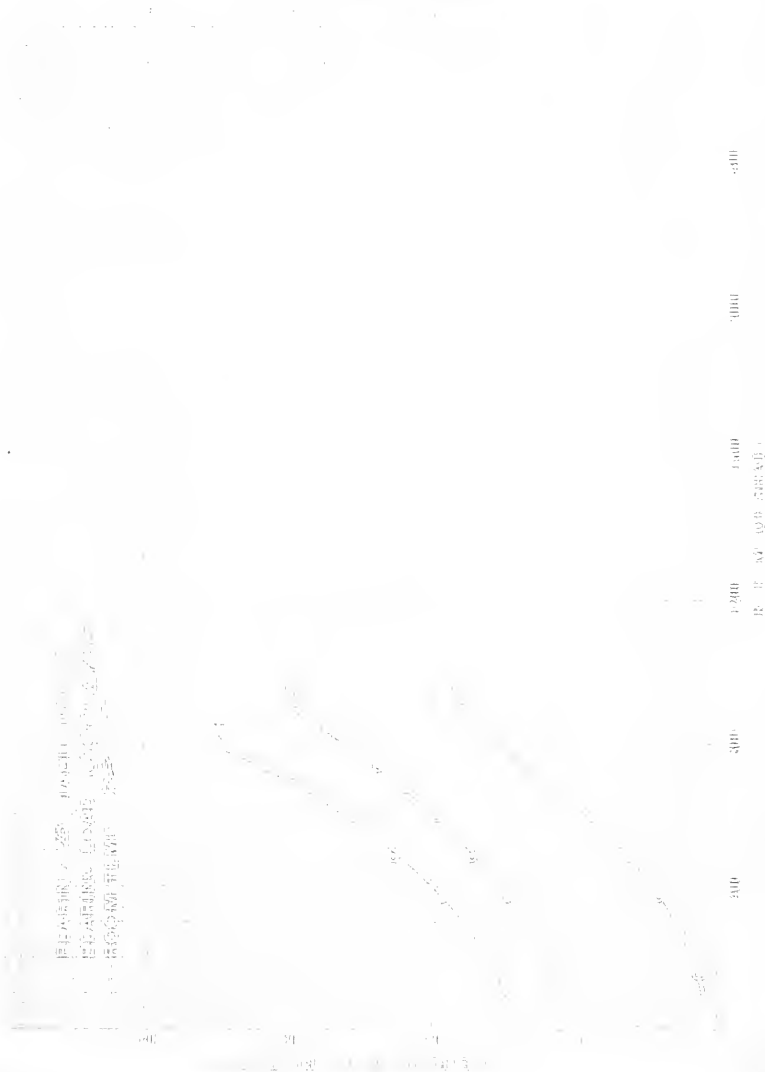
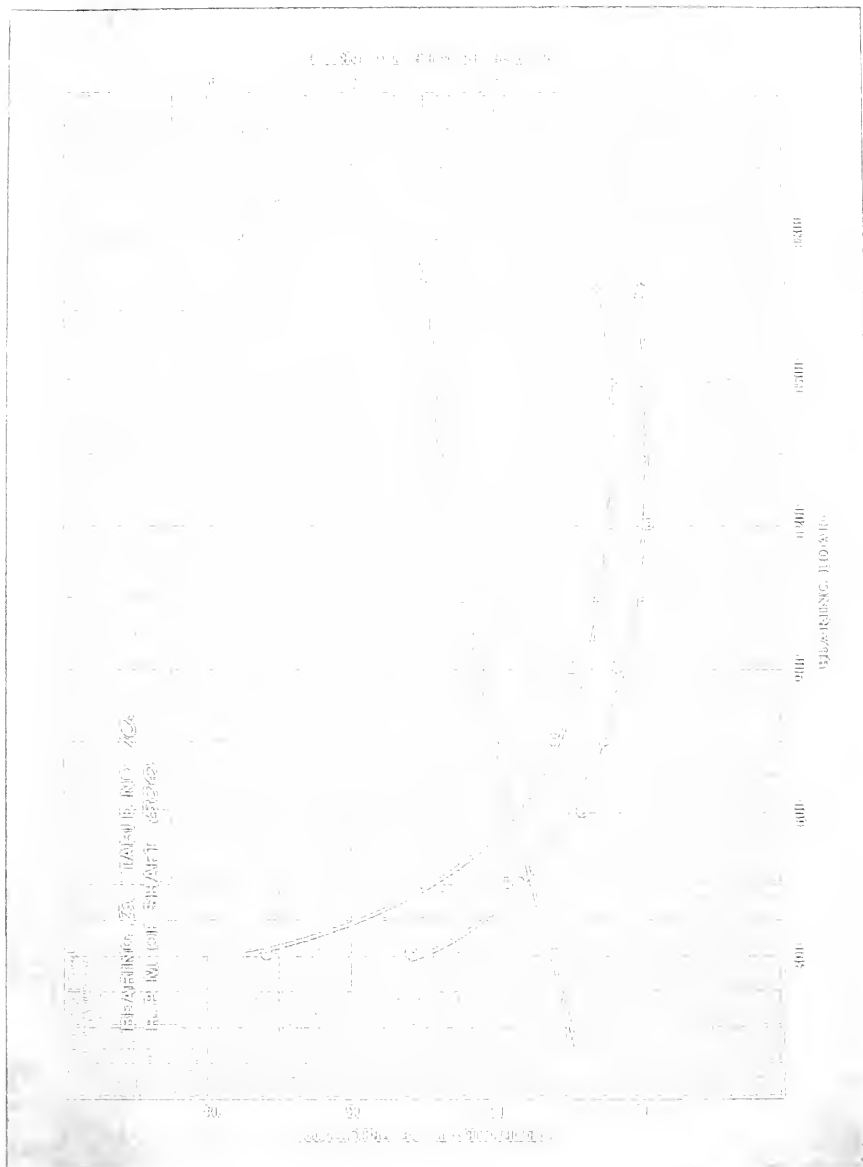
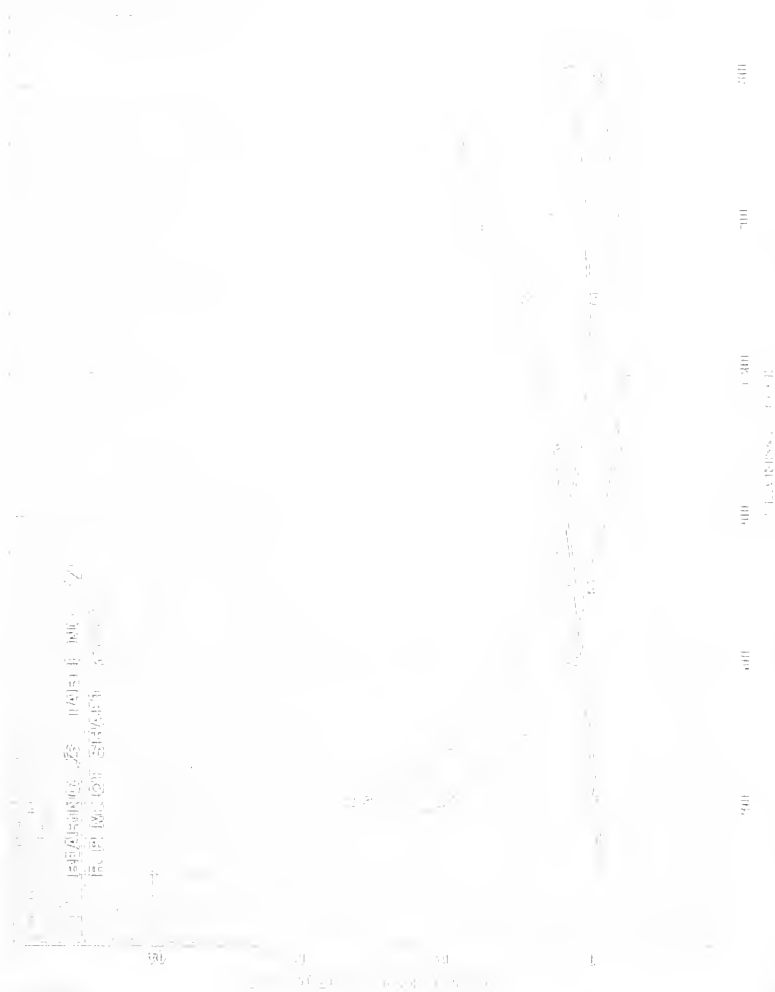


Figure 1







"BEARING "C"



Fig. 9

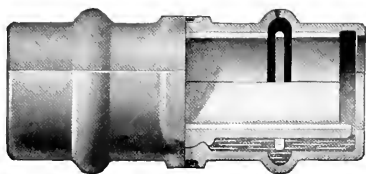


Fig. 10

BEARING "C"

Bearing "C", (Figures 9,10), is the ordinary type of ring oiled babbitt bearing. The housing contains the oil which is carried up from the reservoir to the top of the shaft from whence it is distributed along the whole bearing length. The bottom piece of babbitt is detachable and fits into the lower housing, while the top babbitt is fixed into the upper housing. The babbitt contained no oil grooves.

When this type of bearing is new, it is very economical and its coefficient of friction is low. The reason for this being that the babbitt has high spots on which the shaft runs and because the shaft runs on the high spots, the oil is pressed into the low spots at enormous pressures, thereby, giving the shaft a pressure feed oil lubrication which of necessity lowered the friction in the bearings. After the completion of the tests

on this type of bearing it was found that the bearings had only been worn on two or three high spots.

The fact that in time the high spots on the bearing will wear down so that the shaft will run on the entire babbitt surface does not mean that the friction will be less. To the contrary, the more bearing surface the shaft has, the less oil space it has and the higher the friction will be. In journal bearings, the better the lubrication, the lower the friction.

At no time during the test were we able to start the line shaft with any load on. The bearings were all as loosely adjusted as it was possible to make them, but, even so, the 20 H.P. dynamometer would not turn over the shaft when the load was on. This is certainly a very objectionable feature of this bearing. It shows that the starting or slow moving sliding friction is a long way out of proportion to that of rolling friction.



TABLES 1 - 16

OF

BEARING "C"

B E A R I N G C

Table No. 1 Date July 9th, 1915.
 Bearing Load, LBS. 1500 Time, beginning of run 8:50 A.M.
 Room Temp.° Fahr. 69 Time, end of run 9:20 A.M.
 Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE | | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|--------|-------|-------------------------|-------------------------|---------|
| | | Inch | Lbs. | | Shaft | Bearing |
| 0.63 | 1474 | 19.85 | 0.465 | 0.0109 | | |
| 0.555 | 1392 | 17.48 | 0.387 | 0.0096 | | |
| 0.495 | 1187 | 15.58 | 0.294 | 0.0085 | | |
| 0.46 | 979 | 14.48 | 0.225 | 0.0079 | | |
| 0.445 | 888 | 14.02 | 0.198 | 0.0077 | | |
| 0.425 | 845 | 13.38 | 0.180 | 0.0073 | | |
| 0.43 | 807 | 12.75 | 0.164 | 0.0070 | | |
| 0.385 | 750 | 12.11 | 0.144 | 0.0066 | | |
| 0.375 | 688 | 11.80 | 0.129 | 0.0065 | | |
| 0.365 | 598 | 11.50 | 0.109 | 0.0063 | | |
| 0.335 | 497 | 10.55 | 0.083 | 0.0058 | | |
| 0.34 | 382 | 10.70 | 0.065 | 0.0059 | | |
| 0.34 | 317 | 10.70 | 0.053 | 0.0059 | | |
| 0.345 | 302 | 10.85 | 0.052 | 0.0060 | | |

Remarks:—

B E A R I N G C

Table No. 2 Date July 9th, 1915.
 Bearing Load, LBS. 1350 Time, beginning of run 9:20 A.M.
 Room Temp. ° Fahr. 69 Time, end of run 9:42 A.M.
 Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE | | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|--------|-------|-------------------------|-------------------------|---------|
| | | Inch | Lbs. | | Shaft | Bearing |
| 0.485 | 1508 | 15.28 | 0.366 | 0.0093 | | |
| 0.44 | 1369 | 13.82 | 0.301 | 0.0084 | | |
| 0.385 | 1043 | 12.11 | 0.201 | 0.0074 | | |
| 0.365 | 914 | 11.47 | 0.167 | 0.0070 | | |
| 0.355 | 845 | 11.17 | 0.150 | 0.0068 | | |
| 0.34 | 763 | 10.30 | 0.126 | 0.0063 | | |
| 0.32 | 688 | 10.07 | 0.110 | 0.0061 | | |
| 0.305 | 538 | 9.61 | 0.082 | 0.0058 | | |
| 0.30 | 382 | 9.45 | 0.057 | 0.0057 | | |
| 0.30 | 290 | 9.45 | 0.044 | 0.0057 | | |
| 0.315 | 262 | 9.93 | 0.041 | 0.0060 | | |
| 0.32 | 240 | 10.07 | 0.038 | 0.0061 | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Remarks:—

B E A R I N G C

Table No. 3 Date July 9th, 1915.
 Bearing Load, LBS. 1200 Time, beginning of run 9:42 A.M.
 Room Temp.° Fahr. 69 Time, end of run 9:58 A.M.
 Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE
Inch Lbs. | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|---------------------|-------------------------|-------------------------|---------|
| | | | | Shaft | Bearing |
| 0.465 | 1620 | 13.08 | 0.337 | 0.0090 | |
| 0.37 | 1386 | 11.64 | 0.257 | 0.0080 | |
| 0.32 | 1060 | 10.08 | 0.169 | 0.0069 | |
| 0.295 | 920 | 9.28 | 0.136 | 0.0064 | |
| 0.28 | 833 | 8.82 | 0.117 | 0.0061 | |
| 0.27 | 773 | 8.50 | 0.104 | 0.0058 | |
| 0.255 | 653 | 8.04 | 0.083 | 0.0055 | |
| 0.245 | 530 | 7.72 | 0.065 | 0.0053 | |
| 0.225 | 328 | 7.08 | 0.037 | 0.0049 | |
| 0.24 | 242 | 7.56 | 0.029 | 0.0052 | |
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Remarks:—

B E A R I N G C

Table No. 4 Date July 9th, 1915.

Bearing Load, LBS. 1050 Time, beginning of run 9:58 A.M.

Room Temp.° Fahr. 69 Time, end of run 10:15 A.M.

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE
Inch Lbs. | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|---------------------|-------------------------|-------------------------|---------|
| | | | | Shaft | Bearing |
| 0.39 | 1659 | 12.28 | 0.324 | 0.0096 | |
| 0.335 | 1498 | 10.56 | 0.251 | 0.0083 | |
| 0.29 | 1273 | 9.13 | 0.185 | 0.0071 | |
| 0.24 | 934 | 7.56 | 0.112 | 0.0059 | |
| 0.23 | 819 | 7.25 | 0.094 | 0.0057 | |
| 0.225 | 753 | 7.08 | 0.085 | 0.0055 | |
| 0.21 | 607 | 6.62 | 0.064 | 0.0052 | |
| 0.195 | 415 | 6.14 | 0.040 | 0.0048 | |
| 0.195 | 267 | 6.14 | 0.026 | 0.0048 | |
| 0.185 | 223 | 5.83 | 0.021 | 0.0046 | |
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Remarks:—

B E A R I N G C

Table No. 5 Date July 9th, 1915.
 Bearing Load, LBS. 900 Time, beginning of run 10:15 A.M.
 Room Temp.° Fahr. 69 Time, end of run 10:30 A.M.
 Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE | | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|--------|-------|-------------------------|-------------------------|---------|
| | | Inch | Lbs. | | Shaft | Bearing |
| 0.365 | 1618 | 11.50 | 0.295 | 0.0105 | | |
| 0.32 | 1448 | 10.08 | 0.231 | 0.0092 | | |
| 0.28 | 1258 | 8.82 | 0.176 | 0.0081 | | |
| 0.245 | 1118 | 7.73 | 0.137 | 0.0072 | | |
| 0.215 | 933 | 6.78 | 0.100 | 0.0062 | | |
| 0.205 | 863 | 6.46 | 0.088 | 0.0059 | | |
| 0.20 | 796 | 6.30 | 0.080 | 0.0058 | | |
| 0.195 | 728 | 6.46 | 0.075 | 0.0059 | | |
| 0.200 | 561 | 6.30 | 0.056 | 0.0058 | | |
| 0.195 | 481 | 6.14 | 0.047 | 0.0056 | | |
| 0.185 | 373 | 5.83 | 0.035 | 0.0053 | | |
| 0.17 | 276 | 5.36 | 0.024 | 0.0049 | | |
| 0.175 | 240 | 5.52 | 0.021 | 0.0050 | | |
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Remarks:—

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B E A R I N G C

Table No. 6 Date July 9th, 1915.
 Bearing Load, LBS. 750 Time, beginning of run 10:35 A.M.
 Room Temp.° Fahr. 69 Time, end of run 10:50 A.M.
 Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE | | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|--------|------|-------------------------|-------------------------|---------|
| | | Inch | Lbs. | | Shaft | Bearing |
| 0.355 | 1608 | 11.18 | | 0.286 | 0.0122 | |
| 0.315 | 1472 | 9.92 | | 0.232 | 0.0109 | |
| 0.285 | 1274 | 8.98 | | 0.182 | 0.0098 | |
| 0.23 | 1073 | 7.25 | | 0.123 | 0.0080 | |
| 0.215 | 958 | 6.78 | | 0.103 | 0.0074 | |
| 0.20 | 885 | 6.30 | | 0.089 | 0.0069 | |
| 0.19 | 807 | 5.98 | | 0.077 | 0.0066 | |
| 0.185 | 724 | 5.83 | | 0.067 | 0.0064 | |
| 0.175 | 548 | 5.51 | | 0.048 | 0.0060 | |
| 0.165 | 424 | 5.20 | | 0.035 | 0.0057 | |
| 0.155 | 343 | 4.88 | | 0.027 | 0.0054 | |
| 0.155 | 300 | 4.88 | | 0.023 | 0.0054 | |
| 0.15 | 230 | 4.72 | | 0.017 | 0.0052 | |
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Remarks:—

B E A R I N G C

Table No. 7 Date July 9th, 1915.
 Bearing Load, LBS. 700 Time, beginning of run 10:50 A.M.
 Room Temp.° Fahr. 69 Time, end of run 11:05 A.M.
 Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE | | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|--------|-------|-------------------------|-------------------------|---------|
| | | Inch | Lbs. | | Shaft | Bearing |
| 0.325 | 1664 | 10.21 | 0.271 | 0.0140 | | |
| 0.29 | 1500 | 9.13 | 0.218 | 0.0125 | | |
| 0.25 | 1323 | 7.88 | 0.166 | 0.0108 | | |
| 0.22 | 1122 | 6.93 | 0.123 | 0.0095 | | |
| 0.19 | 944 | 5.98 | 0.090 | 0.0082 | | |
| 0.17 | 816 | 5.35 | 0.069 | 0.0073 | | |
| 0.145 | 621 | 4.56 | 0.045 | 0.0063 | | |
| 0.125 | 373 | 3.94 | 0.023 | 0.0054 | | |
| 0.115 | 264 | 3.62 | 0.015 | 0.0050 | | |
| 0.11 | 203 | 3.46 | 0.011 | 0.0047 | | |
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Remarks:—

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B E A R I N G C

Table No. 8 Date July 9th, 1915.

Bearing Load, LBS. 450 Time, beginning of run 11:05 A.M.

Room Temp.° Fahr. 69 Time, end of run 11:21 A.M.

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE | | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|--------|------|-------------------------|-------------------------|---------|
| | | Inch | Lbs. | | Shaft | Bearing |
| 0.29 | 1660 | 9.13 | | 0.241 | 0.0167 | |
| 0.27 | 1583 | 8.50 | | 0.214 | 0.0155 | |
| 0.245 | 1463 | 7.72 | | 0.179 | 0.0141 | |
| 0.225 | 1224 | 7.08 | | 0.137 | 0.0129 | |
| 0.405 | 1177 | 6.46 | | 0.121 | 0.0118 | |
| 0.175 | 967 | 5.51 | | 0.085 | 0.0101 | |
| 0.155 | 860 | 4.88 | | 0.067 | 0.0089 | |
| 0.145 | 760 | 4.57 | | 0.055 | 0.0084 | |
| 0.12 | 525 | 3.78 | | 0.032 | 0.0069 | |
| 0.12 | 411 | 3.78 | | 0.025 | 0.0069 | |
| 0.10 | 230 | 3.15 | | 0.012 | 0.0058 | |
| 0.08 | 168 | 2.52 | | 0.007 | 0.0046 | |
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Remarks:—

B E A R I N G C

Table No. 9 Date July 9th, 1915.

Bearing Load, LBS. 300 Time, beginning of run 11:21 A.M.

Room Temp.° Fahr. 69 Time, end of run 11:38 A.M.

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE | | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|--------|------|-------------------------|-------------------------|---------|
| | | Inch | Lbs. | | Shaft | Bearing |
| 0.25 | 1660 | 7.88 | | 0.208 | 0.0216 | |
| 0.235 | 1611 | 7.40 | | 0.189 | 0.0203 | |
| 0.22 | 1503 | 6.93 | | 0.165 | 0.0190 | |
| 0.205 | 1248 | 6.46 | | 0.128 | 0.0177 | |
| 0.17 | 1137 | 5.36 | | 0.097 | 0.0147 | |
| 0.145 | 979 | 4.57 | | 0.071 | 0.0125 | |
| 0.135 | 888 | 4.25 | | 0.060 | 0.0117 | |
| 0.13 | 818 | 4.09 | | 0.053 | 0.0112 | |
| 0.115 | 660 | 3.62 | | 0.038 | 0.0099 | |
| 0.105 | 535 | 3.31 | | 0.028 | 0.0091 | |
| 0.095 | 396 | 2.99 | | 0.019 | 0.0082 | |
| 0.075 | 236 | 2.36 | | 0.009 | 0.0065 | |
| 0.07 | 180 | 2.21 | | 0.006 | 0.0061 | |
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Remarks:—

DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ C _____

R. P. M. of Shaft _____ 1600 _____

Table No. _____ 10 _____

| Bearing Load | Horse Power to Drive | COEFFICIENT OF FRICTION | |
|--------------|----------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | | 0.012 | |
| 1350 | 0.415 | 0.01 | |
| 1200 | 0.336 | 0.0088 | |
| 1050 | 0.29 | 0.0092 | |
| 900 | 0.29 | 0.0105 | |
| 750 | 0.285 | 0.0125 | |
| 600 | 0.245 | 0.0135 | |
| 450 | 0.225 | 0.016 | |
| 300 | 0.25 | 0.0195 | |
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Remarks:—

DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ C _____

R. P. M. of Shaft _____ 1200 _____

Table No. 11 _____

| Bearing Load | Horse Power to Drive | COEFFICIENT OF FRICTION | |
|--------------|----------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.32 | 0.0092 | |
| 1350 | 0.26 | 0.008 | |
| 1200 | 0.21 | 0.0075 | |
| 1050 | 0.182 | 0.007 | |
| 900 | 0.162 | 0.0076 | |
| 750 | 0.16 | 0.009 | |
| 600 | 0.142 | 0.0098 | |
| 450 | 0.128 | 0.0126 | |
| 300 | 0.115 | 0.017 | |
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Remarks:—



DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ C _____

R. P. M. of Shaft _____ 1000 _____

Table No. 12 _____

| Bearing
Load | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------|-------------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.23 | 0.008 | |
| 1350 | 0.195 | 0.007 | |
| 1200 | 0.155 | 0.007 | |
| 1050 | 0.137 | 0.006 | |
| 900 | 0.12 | 0.0066 | |
| 750 | 0.12 | 0.0077 | |
| 600 | 0.10 | 0.0084 | |
| 450 | 0.11 | 0.009 | |
| 300 | 0.135 | 0.008 | |
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Remarks:—

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DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ C _____

R. P. M. of Shaft _____ 800 _____

Table No. **13** _____

| Bearing Load | Horse Power to Drive | COEFFICIENT OF FRICTION | |
|--------------|----------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.16 | 0.007 | |
| 1350 | 0.14 | 0.0065 | |
| 1200 | 0.11 | 0.0063 | |
| 1050 | 0.10 | 0.0065 | |
| 900 | 0.077 | 0.0066 | |
| 750 | 0.076 | 0.0065 | |
| 600 | 0.071 | 0.0067 | |
| 450 | 0.095 | 0.006 | |
| 300 | 0.105 | 0.0053 | |
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DATA INTERPOLATED
FROM TABLES 1-9

Bearing _____ C _____

R. P. M. of Shaft _____ 600 _____

Table No. 14 _____

| Bearing Load | Horse Power to Drive | COEFFICIENT OF FRICTION | |
|--------------|----------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.105 | 0.006 | |
| 1350 | 0.1 | 0.0061 | |
| 1200 | 0.075 | 0.0057 | |
| 1050 | 0.065 | 0.0051 | |
| 900 | 0.047 | 0.0052 | |
| 750 | 0.047 | 0.006 | |
| 600 | 0.04 | 0.0061 | |
| 450 | 0.035 | 0.0078 | |
| 300 | 0.03 | 0.0085 | |
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Remarks:—

DATA INTERPOLATED
FROM TABLES 1-9

Bearing _____ C _____

R. P. M. of Shaft 400

Table No. 15

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Remarks:—



DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ C _____

R. P. M. of Shaft _____ 200 _____

Table No. **16** _____

| Bearing Load | Horse Power to Drive | COEFFICIENT OF FRICTION | |
|--------------|----------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.041 | 0.006 | |
| 1350 | 0.038 | 0.0064 | |
| 1200 | 0.028 | 0.205 | |
| 1050 | 0.022 | 0.0051 | |
| 900 | 0.020 | 0.005 | |
| 750 | 0.020 | 0.0053 | |
| 600 | 0.010 | 0.005 | |
| 450 | 0.008 | 0.0045 | |
| 300 | 0.005 | 0.0056 | |
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Remarks:—

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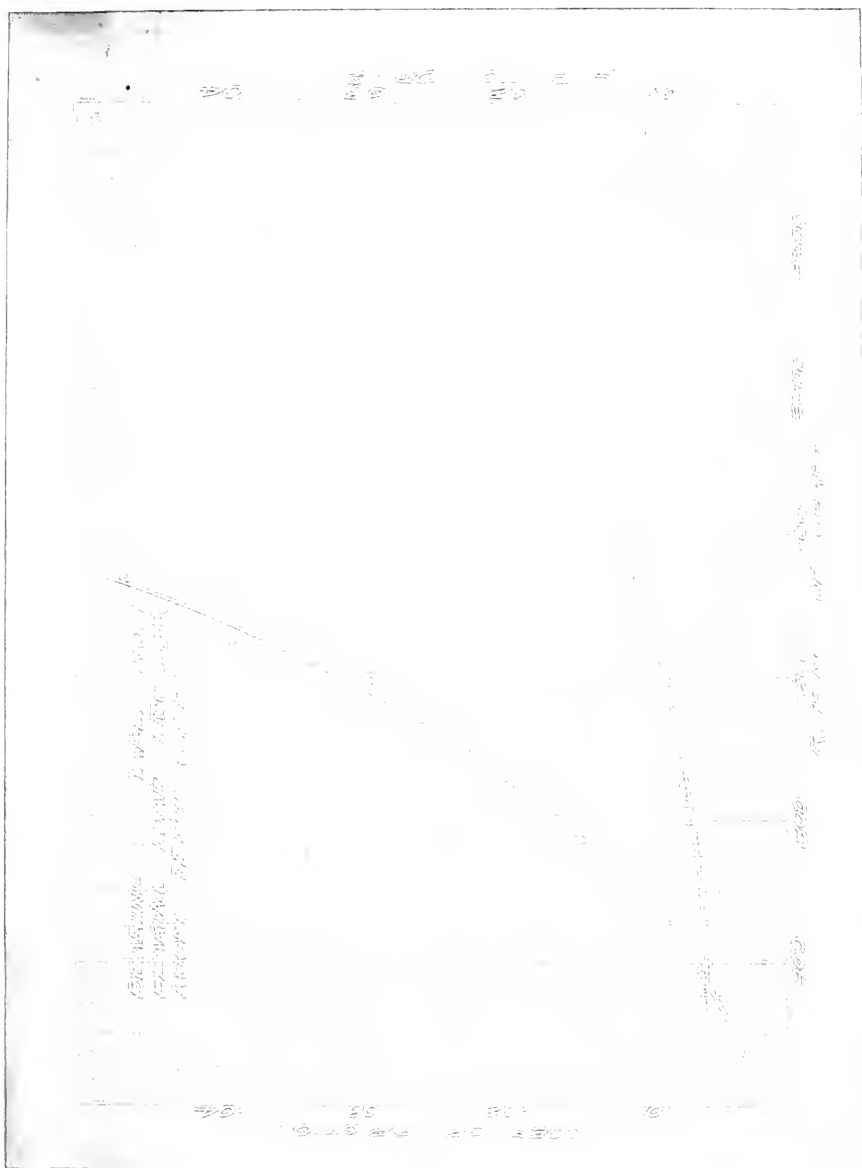
CURVES PLOTTED FROM
TABLES 1 - 16
OF
BEARING "C"

Mr. [Name] [Address]

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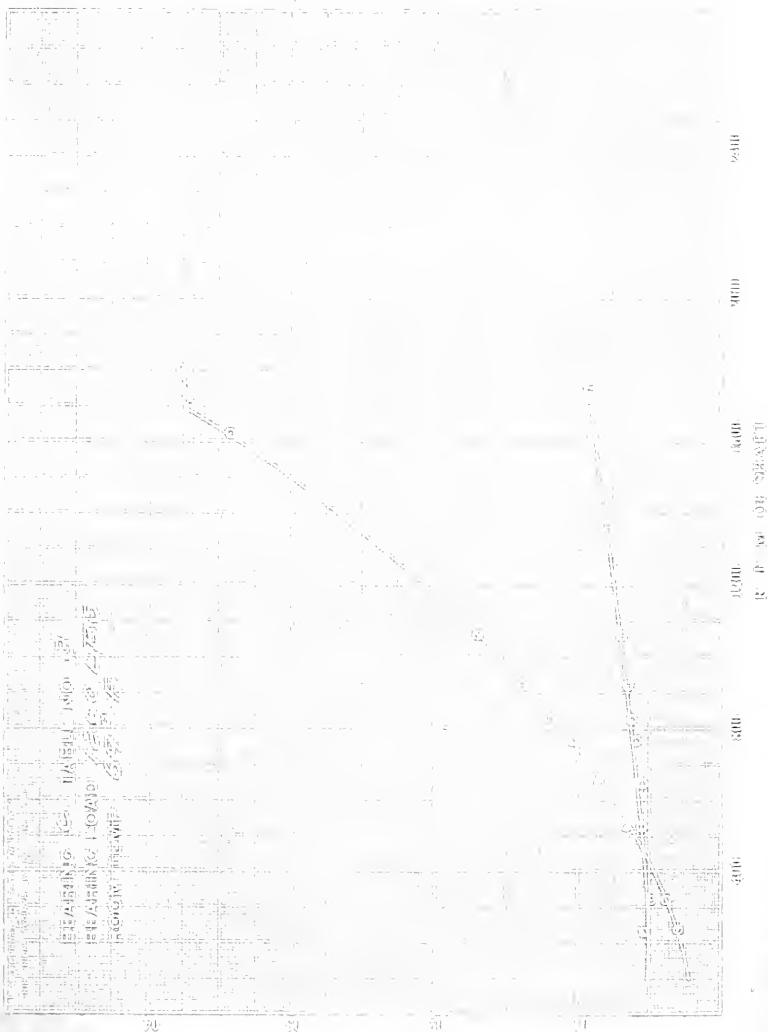
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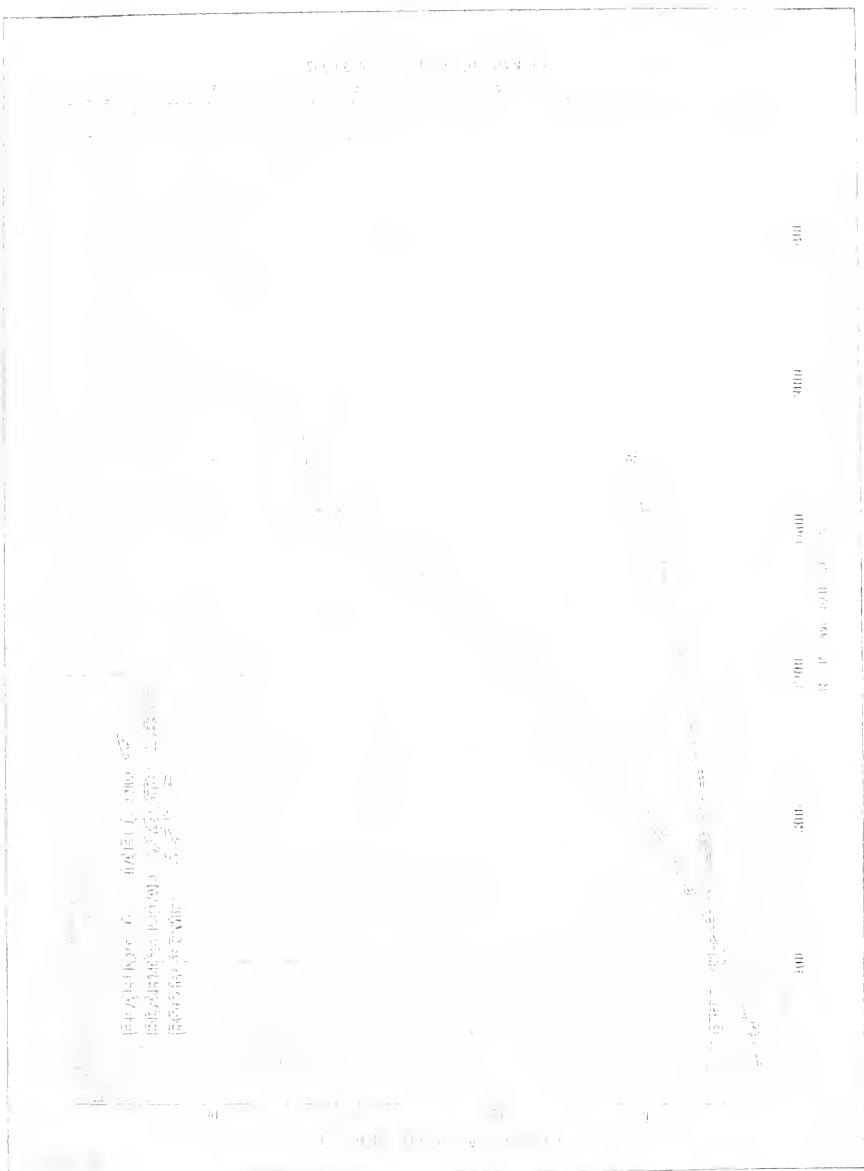
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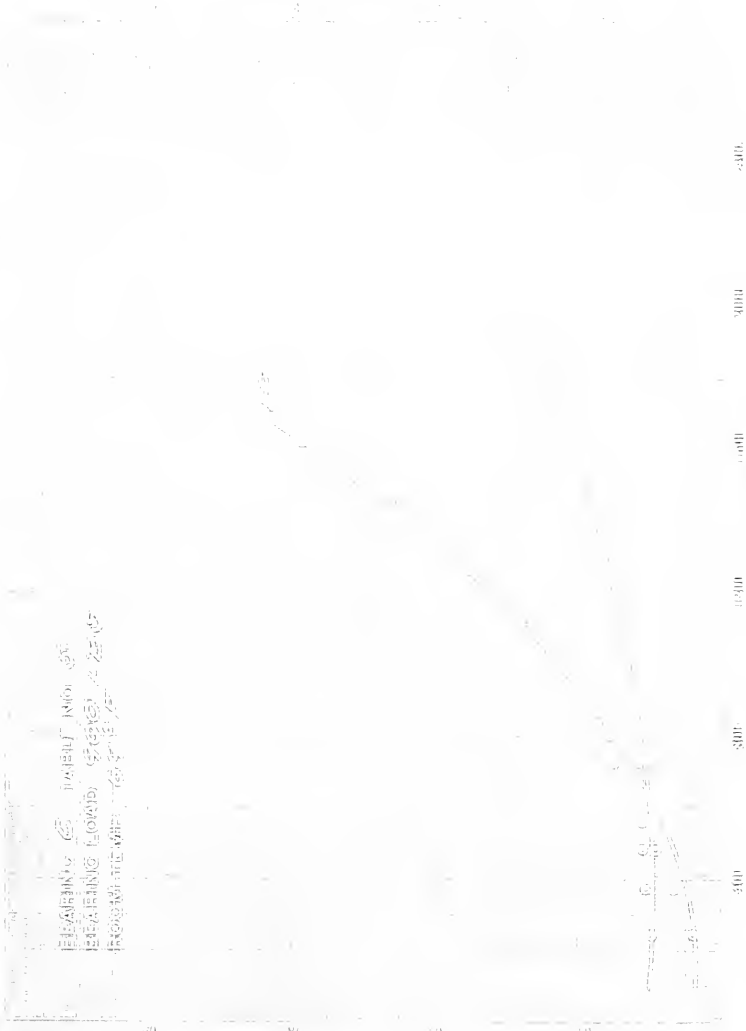
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EXPERIMENTAL TEST



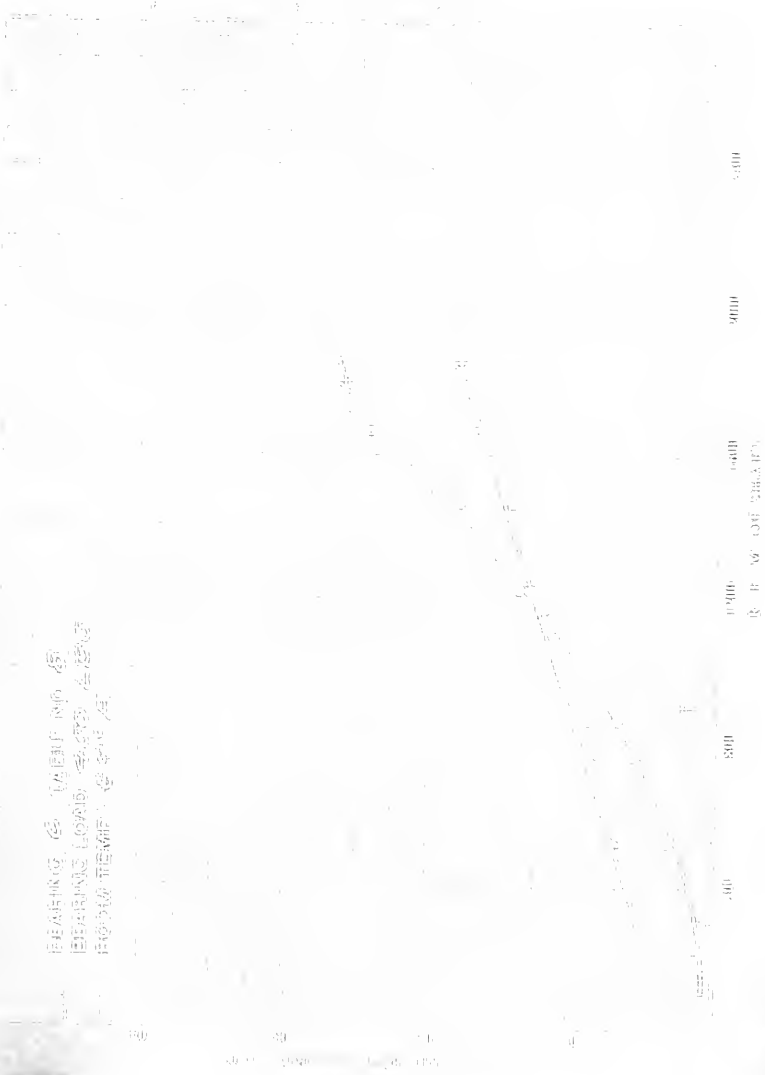
Graph showing the relationship between ...

（以下は、非常に淡く、ほとんど不可読な印刷文字が繰り返されています。文意を正確に転写することはできません。）

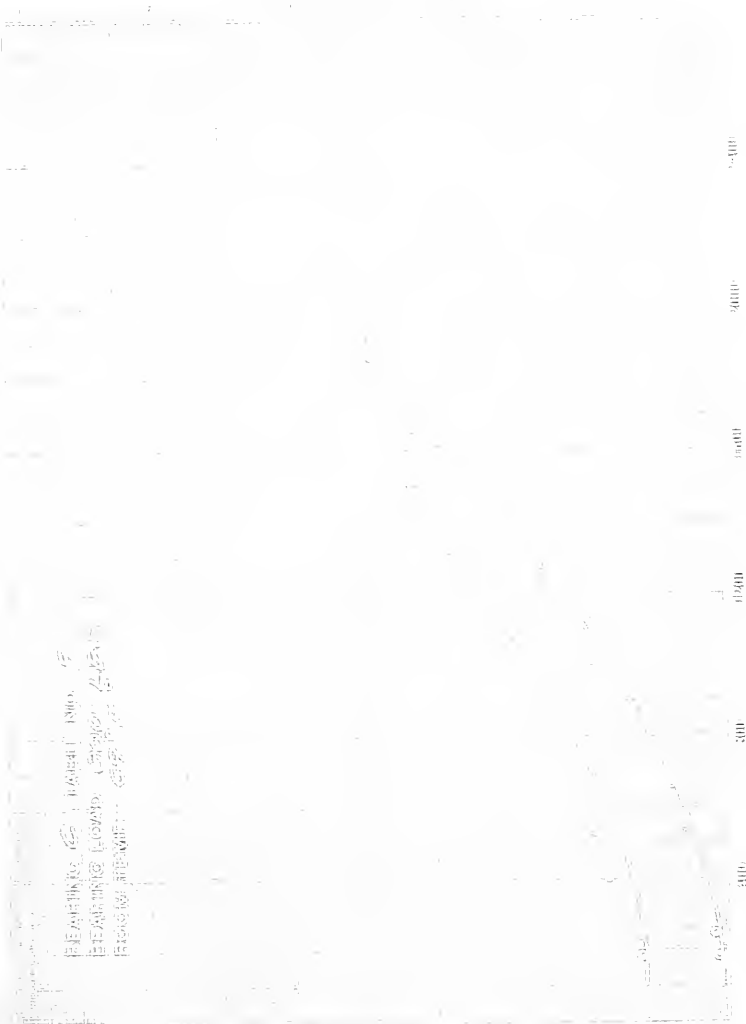
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 十二月
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 第 119 号
 1911 年 12 月 1 日

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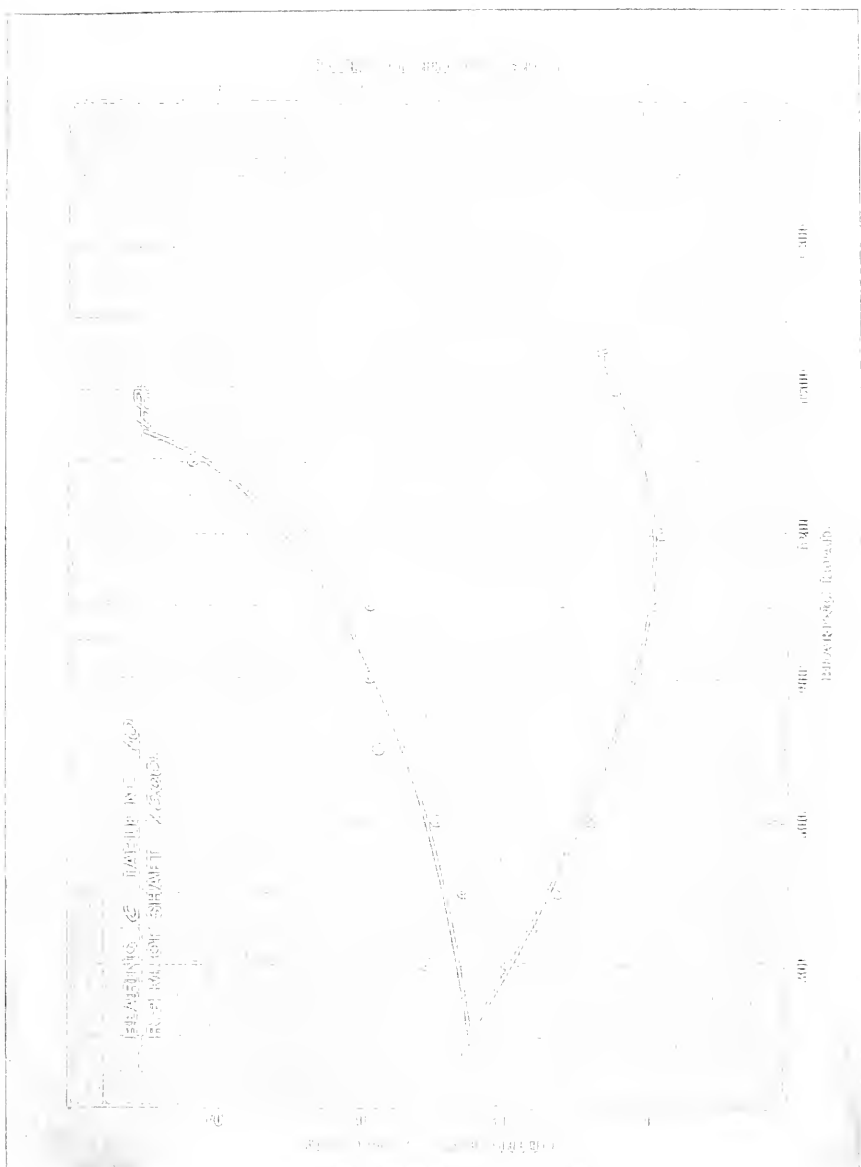
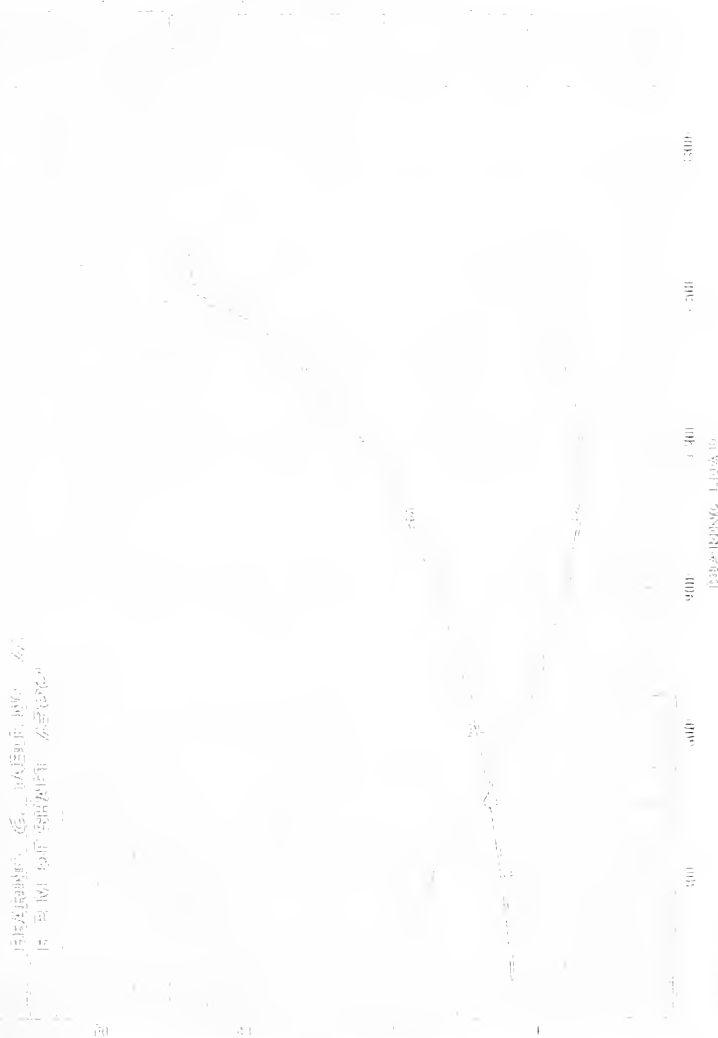


Figure 1. (continued)

Figure 1. (continued)



RESEARCH, TRAINING, AND RESEARCH CENTER

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1. 在 100 个样本中，有 10 个样本是“好”的。
 2. 在 100 个样本中，有 10 个样本是“坏”的。

100 个样本中，有 10 个样本是“好”的。

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100 个样本中，有 10 个样本是“好”的。

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BEARING "D"



Fig. 11

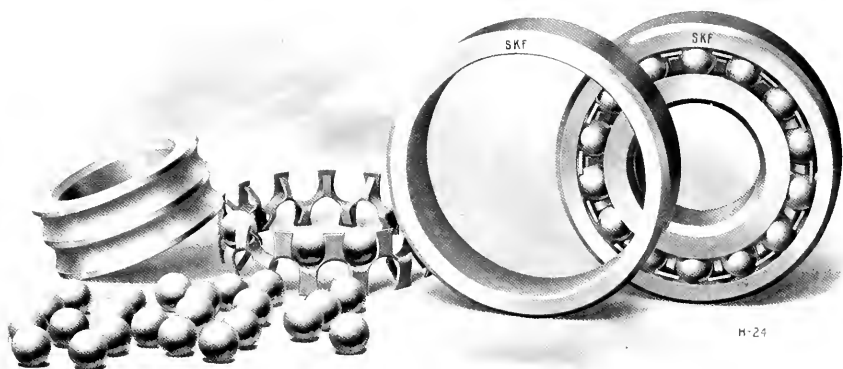


Fig. 12

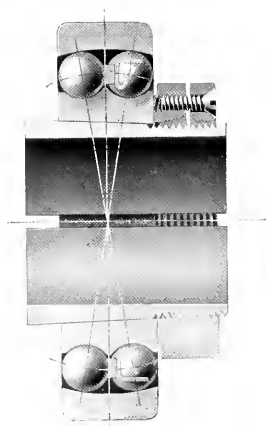


Fig. 13

BEARING "D"

Bearing "D", (Figures 11,12,13), is a self aligning adapter type radial ball bearing. The bearing consists of an outer ball race, an inner ball race, two rows of balls, a retainer for properly spacing and retaining the balls between the raceways and a housing for the whole.

The inner race contains two grooves, each ground to a radius slightly larger than the radius of the balls, while the outer race is ground in the form of a hollow sphere, whose center is the center of the axis of rotation. The balls, the retainer and inner race are free to rotate at any angle within the outer race and will adjust themselves to any possible degree of deflection of the shaft without binding either the balls or raceways.

The balls roll on the surface of the spherically ground outer ball race with a pure rolling motion without sliding friction.

This action is facilitated by the distribution of the load over a large number of balls.

These bearings were found to be highly efficient both in coefficient of friction and horse power to drive, and the reasons for this are plentiful. The friction in a ball bearing is independent of the viscosity of the lubricant or its temperature; the frictional resistance of starting and slow motion is very low. Another advantage it has is that it is more compact.

This type of bearing permits of the use of more balls per bearing, because, the two rows of balls are held in staggered relation by the retainer. This increases the carrying capacity of the bearing. The retainer is made of one piece and it is open at the sides permitting easy cleaning and positive lubrication.

The bearings were found to run absolutely cool at any load and speed and very economical, but, upon taking the bearings apart after the

1. The first step is to identify the problem or question that needs to be answered.

2. The second step is to gather relevant information and data to address the problem.

3. The third step is to analyze the information and data to identify patterns and trends.

4. The fourth step is to develop a hypothesis or a proposed solution based on the analysis.

5. The fifth step is to test the hypothesis or solution through experiments or observations.

6. The sixth step is to evaluate the results of the tests and determine if the hypothesis is supported.

7. The seventh step is to draw conclusions based on the evaluation of the results.

8. The eighth step is to communicate the findings and conclusions to the relevant audience.

9. The ninth step is to reflect on the process and identify areas for improvement.

10. The tenth step is to apply the knowledge and skills gained from the process to other situations.

11. The eleventh step is to continue to learn and grow from the experience.

12. The twelfth step is to share the knowledge and skills with others to help them learn and grow.

13. The thirteenth step is to stay up-to-date on the latest developments in the field.

14. The fourteenth step is to seek out new challenges and opportunities for growth.

15. The fifteenth step is to maintain a positive attitude and a growth mindset.

16. The sixteenth step is to be open to feedback and criticism.

17. The seventeenth step is to be persistent and not give up easily.

18. The eighteenth step is to be collaborative and work well with others.

19. The nineteenth step is to be creative and think outside the box.

20. The twentieth step is to be resilient and bounce back from setbacks.

21. The twenty-first step is to be proactive and take initiative.

22. The twenty-second step is to be organized and manage time effectively.

23. The twenty-third step is to be detail-oriented and thorough.

24. The twenty-fourth step is to be adaptable and flexible.

25. The twenty-fifth step is to be a lifelong learner.

test, it was seen that the ball races had become slightly grooved because of the load. This immediately decreases the efficiency of the bearing, because, there then is an area of contact instead of a point contact.

TABLES 1 - 16
of
BEARING "D"

100 - 100

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100 - 100

B E A R I N G D

Table No. 1 Date July 14th, 1915.

Bearing Load, LBS. 1500 Time, beginning of run 9:25 A.M.

Room Temp.° Fahr. 74 Time, end of run _____

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE
Inch Lbs. | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|---------------------|-------------------------|-------------------------|---------|
| | | | | Shaft | Bearing |
| 0.145 | 2023 | 4.57 | 0.147 | 0.00249 | 0.00148 |
| 0.125 | 1832 | 3.94 | 0.114 | 0.00215 | 0.00129 |
| 0.11 | 1546 | 3.46 | 0.085 | 0.00189 | 0.00113 |
| 0.105 | 1354 | 3.31 | 0.071 | 0.00181 | 0.00108 |
| 0.09 | 1114 | 2.84 | 0.050 | 0.00155 | 0.00092 |
| 0.085 | 872 | 2.67 | 0.037 | 0.00146 | 0.00087 |
| 0.085 | 817 | 2.67 | 0.035 | 0.00146 | 0.00087 |
| 0.08 | 636 | 2.52 | 0.025 | 0.00138 | 0.00082 |
| 0.07 | 496 | 2.20 | 0.017 | 0.00121 | 0.00072 |
| 0.065 | 284 | 2.05 | 0.0092 | 0.00112 | 0.00067 |
| 0.06 | 130 | 1.89 | 0.0039 | 0.00103 | 0.00061 |
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Remarks:—

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B E A R I N G D

Table No. 2 Date July 14th, 1915.

Bearing Load, LBS. 1350 Time, beginning of run _____

Room Temp. ° Fahr. 74 Time, end of run _____

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE | | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|--------|------|-------------------------|-------------------------|---------|
| | | Inch | Lbs. | | Shaft | Bearing |
| 0.115 | 2120 | 3.62 | | 0.122 | 0.00221 | 0.00132 |
| 0.10 | 2003 | 3.15 | | 0.100 | 0.00192 | 0.00114 |
| 0.09 | 1784 | 2.84 | | 0.080 | 0.00173 | 0.00103 |
| 0.085 | 1570 | 2.67 | | 0.0667 | 0.00163 | 0.00097 |
| 0.085 | 1218 | 2.67 | | 0.0517 | 0.00163 | 0.00097 |
| 0.085 | 1115 | 2.67 | | 0.0473 | 0.00163 | 0.00097 |
| 0.08 | 057 | 2.52 | | 0.0382 | 0.00154 | 0.00083 |
| 0.075 | 857 | 2.36 | | 0.0321 | 0.00144 | 0.00086 |
| 0.07 | 730 | 2.20 | | 0.0255 | 0.00134 | 0.00080 |
| 0.065 | 591 | 2.05 | | 0.0192 | 0.00125 | 0.00075 |
| 0.06 | 431 | 1.88 | | 0.0129 | 0.00115 | 0.00069 |
| 0.055 | 316 | 1.73 | | 0.0087 | 0.00105 | 0.00063 |
| 0.05 | 205 | 1.57 | | 0.0051 | 0.00096 | 0.00057 |
| | | | | | | |
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Remarks:— Collar friction eased up at beginning
of run.

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B E A R I N G D

Table No. 3 Date July 14th, 1915.
 Bearing Load, LBS. 1200 Time, beginning of run 10:03 A.M.
 Room Temp.° Fahr. 74 Time, end of run 10:21 A.M.
 Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE
Inch Lbs. | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|---------------------|-------------------------|-------------------------|---------|
| | | | | Shaft | Bearing |
| 0.095 | 2205 | 2.99 | 0.1045 | 0.00205 | 0.00122 |
| 0.085 | 1963 | 2.67 | 0.0835 | 0.00183 | 0.00109 |
| 0.08 | 1753 | 2.52 | 0.0702 | 0.00173 | 0.00103 |
| 0.08 | 1477 | 2.52 | 0.0590 | 0.00173 | 0.00103 |
| 0.075 | 1380 | 2.30 | 0.0518 | 0.00162 | 0.00097 |
| 0.075 | 1127 | 2.39 | 0.0422 | 0.00162 | 0.00097 |
| 0.07 | 975 | 2.20 | 0.0342 | 0.00151 | 0.00090 |
| 0.065 | 882 | 2.05 | 0.0286 | 0.00141 | 0.00084 |
| 0.06 | 831 | 1.89 | 0.0249 | 0.00129 | 0.00077 |
| 0.055 | 659 | 1.73 | 0.0181 | 0.00119 | 0.00071 |
| 0.055 | 498 | 1.73 | 0.0137 | 0.00119 | 0.00071 |
| 0.05 | 329 | 1.57 | 0.0082 | 0.00108 | 0.00064 |
| 0.04 | 125 | 1.26 | 0.0025 | 0.00086 | 0.00051 |
| | | | | | |
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Remarks:—

B E A R I N G D

Table No. 4 Date July 14th, 1915.

Bearing Load, LBS. 1050 Time, beginning of run 10:21 A.M.

Room Temp. ° Fahr. 74 Time, end of run _____

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE
Inch Lbs. | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|---------------------|-------------------------|-------------------------|---------|
| | | | | Shaft | Bearing |
| 0.095 | 2260 | 2.99 | 0.1073 | 0.00234 | 0.00139 |
| 0.09 | 2034 | 2.83 | 0.0915 | 0.00221 | 0.00131 |
| 0.085 | 1768 | 2.67 | 0.0952 | 0.00209 | 0.00125 |
| 0.075 | 1572 | 2.36 | 0.0590 | 0.00184 | 0.00110 |
| 0.07 | 1385 | 2.20 | 0.0485 | 0.00172 | 0.00102 |
| 0.07 | 1125 | 2.20 | 0.0395 | 0.00172 | 0.00102 |
| 0.07 | 974 | 2.20 | 0.0341 | 0.00172 | 0.00102 |
| 0.065 | 869 | 2.05 | 0.0282 | 0.00160 | 0.00095 |
| 0.06 | 747 | 1.89 | 0.0224 | 0.00148 | 0.00088 |
| 0.055 | 590 | 1.73 | 0.0162 | 0.00136 | 0.00081 |
| 0.045 | 342 | 1.42 | 0.0077 | 0.00111 | 0.00066 |
| 0.035 | 146 | 1.10 | 0.0026 | 0.00086 | 0.00051 |
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Remarks:—

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B E A R I N G D

Table No. 5 Date July 14th, 1915.

Bearing Load, LBS. 900 Time, beginning of run _____

Room Temp.° Fahr. 74 Time, end of run _____

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE | | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|--------|------|-------------------------|-------------------------|---------|
| | | Inch | Lbs. | | Shaft | Bearing |
| 0.09 | 2272 | 2.84 | | 0.1022 | 0.00259 | 0.00155 |
| 0.085 | 1994 | 2.67 | | 0.0847 | 0.00244 | 0.00146 |
| 0.08 | 1722 | 2.52 | | 0.0690 | 0.00230 | 0.00137 |
| 0.07 | 1505 | 2.20 | | 0.0537 | 0.00205 | 0.00122 |
| 0.065 | 1272 | 2.05 | | 0.0414 | 0.00187 | 0.00111 |
| 0.065 | 1158 | 2.05 | | 0.0377 | 0.00187 | 0.00111 |
| 0.065 | 964 | 2.05 | | 0.0314 | 0.00187 | 0.00111 |
| 0.065 | 902 | 2.05 | | 0.0292 | 0.00187 | 0.00111 |
| 0.055 | 804 | 1.73 | | 0.0221 | 0.00158 | 0.00094 |
| 0.045 | 618 | 1.42 | | 0.0139 | 0.00130 | 0.00078 |
| 0.035 | 328 | 1.10 | | 0.0058 | 0.00100 | 0.00060 |
| 0.03 | 125 | 0.95 | | 0.0019 | 0.00087 | 0.00057 |
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Remarks:—

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B E A R I N G D

Table No. 6 Date July 14th, 1915.
 Bearing Load, LBS. 750 Time, beginning of run _____
 Room Temp.° Fahr. 74 Time, end of run 11:04 A.M.
 Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE
Inch Lbs. | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|---------------------|-------------------------|-------------------------|---------|
| | | | | Shaft | Bearing |
| 0.085 | 2307 | 2.67 | 0.0981 | 0.00292 | 0.00174 |
| 0.075 | 2053 | 2.36 | 0.0770 | 0.00258 | 0.00154 |
| 0.065 | 1761 | 2.05 | 0.0573 | 0.00224 | 0.00134 |
| 0.06 | 1601 | 1.89 | 0.0483 | 0.00207 | 0.00124 |
| 0.055 | 1274 | 1.73 | 0.0350 | 0.00189 | 0.00113 |
| 0.055 | 1157 | 1.73 | 0.0318 | 0.00189 | 0.00113 |
| 0.055 | 983 | 1.73 | 0.0270 | 0.00189 | 0.00113 |
| 0.05 | 876 | 1.58 | 0.0219 | 0.00173 | 0.00103 |
| 0.045 | 788 | 1.42 | 0.0178 | 0.00156 | 0.00093 |
| 0.04 | 616 | 1.26 | 0.0123 | 0.00138 | 0.00082 |
| 0.35 | 445 | 1.10 | 0.0078 | 0.00120 | 0.00072 |
| 0.025 | 210 | 0.79 | 0.0026 | 0.00087 | 0.00057 |
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Remarks:—

B E A R I N G D

Table No. 7 Date July 14th, 1915.

Bearing Load, LBS. 600 Time, beginning of run 11:04 A.M.

Room Temp.° Fahr. 74 Time, end of run _____

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE
Inch Lbs. | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|---------------------|-------------------------|-------------------------|---------|
| | | | | Shaft | Bearing |
| 0.08 | 2310 | 2.52 | 0.0925 | 0.00345 | 0.00206 |
| 0.07 | 2012 | 2.21 | 0.0705 | 0.00303 | 0.00187 |
| 0.06 | 1731 | 1.89 | 0.0519 | 0.00259 | 0.00155 |
| 0.055 | 1451 | 1.73 | 0.0400 | 0.00237 | 0.00141 |
| 0.05 | 1255 | 1.58 | 0.0314 | 0.00216 | 0.00129 |
| 0.05 | 1170 | 1.58 | 0.0293 | 0.00216 | 0.00129 |
| 0.05 | 1004 | 1.58 | 0.0251 | 0.00216 | 0.00129 |
| 0.045 | 936 | 1.42 | 0.0211 | 0.00194 | 0.00116 |
| 0.045 | 822 | 1.42 | 0.0185 | 0.00194 | 0.00116 |
| 0.04 | 700 | 1.26 | 0.0140 | 0.00172 | 0.00103 |
| 0.03 | 513 | 0.95 | 0.0077 | 0.00129 | 0.00077 |
| 0.03 | 350 | 0.95 | 0.0053 | 0.00129 | 0.00077 |
| 0.0225 | 150 | 0.71 | 0.0017 | 0.00097 | 0.00058 |
| | | | | | |
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Remarks:—

B E A R I N G D

Table No. 8 Date July 14th, 1915.

Bearing Load, LBS. 450 Time, beginning of run _____

Room Temp.° Fahr. 74 Time, end of run _____

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE
Inch Lbs. | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|---------------------|-------------------------|-------------------------|---------|
| | | | | Shaft | Bearing |
| 0.075 | 2293 | 2.36 | 0.0860 | 0.00432 | 0.00251 |
| 0.065 | 2034 | 2.05 | 0.0661 | 0.00375 | 0.00223 |
| 0.055 | 1689 | 1.73 | 0.0464 | 0.00316 | 0.00188 |
| 0.05 | 1554 | 1.58 | 0.0388 | 0.00289 | 0.00172 |
| 0.05 | 1403 | 1.58 | 0.0351 | 0.00289 | 0.00172 |
| 0.045 | 1160 | 1.42 | 0.0261 | 0.00259 | 0.00154 |
| 0.045 | 986 | 1.42 | 0.0222 | 0.00259 | 0.00154 |
| 0.04 | 900 | 1.26 | 0.0180 | 0.00230 | 0.00137 |
| 0.04 | 837 | 1.26 | 0.0167 | 0.00230 | 0.00137 |
| 0.035 | 704 | 1.10 | 0.0123 | 0.00201 | 0.00120 |
| 0.025 | 333 | 0.79 | 0.0042 | 0.00141 | 0.00086 |
| 0.02 | 130 | 0.63 | 0.0013 | 0.00115 | 0.00069 |
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Remarks:—

B E A R I N G D

Table No. 9 Date July 14th, 1915.

Bearing Load, LBS. 300 Time, beginning of run _____

Room Temp.° Fahr. 74 Time, end of run 12:00 M.

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE | | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|--------|------|-------------------------|-------------------------|---------|
| | | Inch | Lbs. | | Shaft | Bearing |
| 0.075 | 2400 | 2.36 | | 0.0900 | 0.00647 | 0.00386 |
| 0.065 | 2184 | 2.05 | | 0.0712 | 0.00563 | 0.00336 |
| 0.06 | 1924 | 1.89 | | 0.0578 | 0.00519 | 0.00309 |
| 0.055 | 1687 | 1.73 | | 0.0464 | 0.00475 | 0.00283 |
| 0.05 | 1594 | 1.58 | | 0.0398 | 0.00433 | 0.00258 |
| 0.045 | 1264 | 1.42 | | 0.0285 | 0.00390 | 0.00232 |
| 0.045 | 1117 | 1.42 | | 0.0252 | 0.00390 | 0.00232 |
| 0.05 | 985 | 1.58 | | 0.0246 | 0.00433 | 0.00258 |
| 0.055 | 876 | 1.73 | | 0.0242 | 0.00475 | 0.00283 |
| 0.055 | 679 | 1.73 | | 0.0187 | 0.00475 | 0.00283 |
| 0.05 | 483 | 1.58 | | 0.0121 | 0.00433 | 0.00258 |
| 0.045 | 290 | 1.42 | | 0.0065 | 0.00390 | 0.00232 |
| 0.04 | 151 | 1.26 | | 0.0031 | 0.00346 | 0.00206 |
| 0.02 | 88 | 0.63 | | 0.0009 | 0.00173 | 0.00103 |

Remarks:— Excessive collar friction during run.

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DATA INTERPOLATED
FROM TABLES 1—9

Bearing D

R. P. M. of Shaft 2000

Table No. 10

| Bearing
Load | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------|-------------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.145 | 0.0024 | 0.00155 |
| 1350 | 0.104 | 0.0022 | 0.0013 |
| 1200 | 0.092 | 0.0019 | 0.0011 |
| 1050 | 0.091 | 0.0023 | 0.0014 |
| 900 | 0.08 | 0.0025 | 0.0015 |
| 750 | 0.07 | 0.0025 | 0.0015 |
| 600 | 0.068 | 0.003 | 0.0017 |
| 450 | 0.06 | 0.0036 | 0.0025 |
| 300 | 0.06 | 0.0051 | 0.0033 |
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Remarks:—

DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ D _____

R. P. M. of Shaft _____ 1600 _____

Table No. 11 _____

| Bearing
Load | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------|-------------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.087 | 0.002 | 0.0012 |
| 1350 | 0.065 | 0.002 | 0.001 |
| 1200 | 0.065 | 0.0017 | 0.0009 |
| 1050 | 0.067 | 0.002 | 0.0012 |
| 900 | 0.051 | 0.002 | 0.0012 |
| 750 | 0.048 | 0.0021 | 0.0012 |
| 600 | 0.042 | 0.0025 | 0.0013 |
| 450 | 0.042 | 0.0028 | 0.0017 |
| 300 | 0.043 | 0.0041 | 0.0026 |
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Remarks:—

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DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ D _____

R. P. M. of Shaft _____ 1200 _____

Table No. 12 _____

| Bearing Load | Horse Power to Drive | COEFFICIENT OF FRICTION | |
|--------------|----------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.056 | 0.0017 | 0.001 |
| 1350 | 0.043 | 0.0015 | 0.0009 |
| 1200 | 0.04 | 0.0015 | 0.0007 |
| 1050 | 0.044 | 0.0017 | 0.0009 |
| 900 | 0.031 | 0.0018 | 0.001 |
| 750 | 0.032 | 0.002 | 0.001 |
| 600 | 0.028 | 0.0022 | 0.0011 |
| 450 | 0.028 | 0.0024 | 0.0014 |
| 300 | 0.031 | 0.0038 | 0.0024 |
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Remarks:—



DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ D _____

R. P. M. of Shaft _____ 800 _____

Table No. **13** _____

| Bearing
Load | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------|-------------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.035 | 0.0014 | 0.0007 |
| 1350 | 0.026 | 0.0013 | 0.0005 |
| 1200 | 0.02 | 0.0012 | 0.0005 |
| 1050 | 0.024 | 0.0015 | 0.0006 |
| 900 | 0.02 | 0.0015 | 0.0006 |
| 750 | 0.02 | 0.0019 | 0.0009 |
| 600 | 0.015 | 0.002 | 0.0009 |
| 450 | 0.016 | 0.002 | 0.0011 |
| 300 | 0.021 | 0.0047 | 0.0021 |
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Remarks:—

DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ D _____

R. P. M. of Shaft _____ 600 _____

Table No. 14 _____

| Bearing Load | Horse Power to Drive | COEFFICIENT OF FRICTION | |
|--------------|----------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.024 | 0.0012 | 0.0005 |
| 1350 | 0.018 | 0.0011 | 0.0004 |
| 1200 | 0.012 | 0.001 | 0.0004 |
| 1050 | 0.015 | 0.0013 | 0.0005 |
| 900 | 0.015 | 0.0014 | 0.0005 |
| 750 | 0.015 | 0.0016 | 0.0008 |
| 600 | 0.011 | 0.0018 | 0.0008 |
| 450 | 0.01 | 0.0019 | 0.0010 |
| 300 | 0.017 | 0.005 | 0.0032 |
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Remarks:—

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| 1 | 2 | 3 | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 |
| 11 | 12 | 13 | 14 | 15 |
| 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 |
| 31 | 32 | 33 | 34 | 35 |
| 36 | 37 | 38 | 39 | 40 |
| 41 | 42 | 43 | 44 | 45 |
| 46 | 47 | 48 | 49 | 50 |

DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ D _____

R. P. M. of Shaft _____ 400 _____

Table No. **15** _____

| Bearing
Load | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------|-------------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.014 | 0.001 | 0.0005 |
| 1350 | 0.011 | 0.001 | 0.0003 |
| 1200 | 0.007 | 0.001 | 0.0003 |
| 1050 | 0.008 | 0.0011 | 0.0004 |
| 900 | 0.01 | 0.001 | 0.0004 |
| 750 | 0.008 | 0.0015 | 0.0006 |
| 600 | 0.005 | 0.0015 | 0.0004 |
| 450 | 0.006 | 0.0016 | 0.0010 |
| 300 | 0.012 | 0.0045 | 0.0028 |
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Remarks:—

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DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ D _____

R. P. M. of Shaft _____ 200 _____

Table No. 16 _____

| Bearing Load | Horse Power to Drive | COEFFICIENT OF FRICTION | |
|--------------|----------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.007 | 0.001 | 0.0004 |
| 1350 | 0.004 | 0.001 | 0.0003 |
| 1200 | 0.004 | 0.001 | 0.0003 |
| 1050 | 0.004 | 0.001 | 0.0003 |
| 900 | 0.004 | 0.001 | 0.0003 |
| 750 | 0.003 | 0.0009 | 0.0002 |
| 600 | 0.003 | 0.0009 | 0.0002 |
| 450 | 0.002 | 0.0013 | 0.0008 |
| 300 | 0.007 | 0.003 | 0.002 |
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Remarks:—

CURVES PLOTTED FROM
TABLES 1 - 16
OF
BEARING "D"

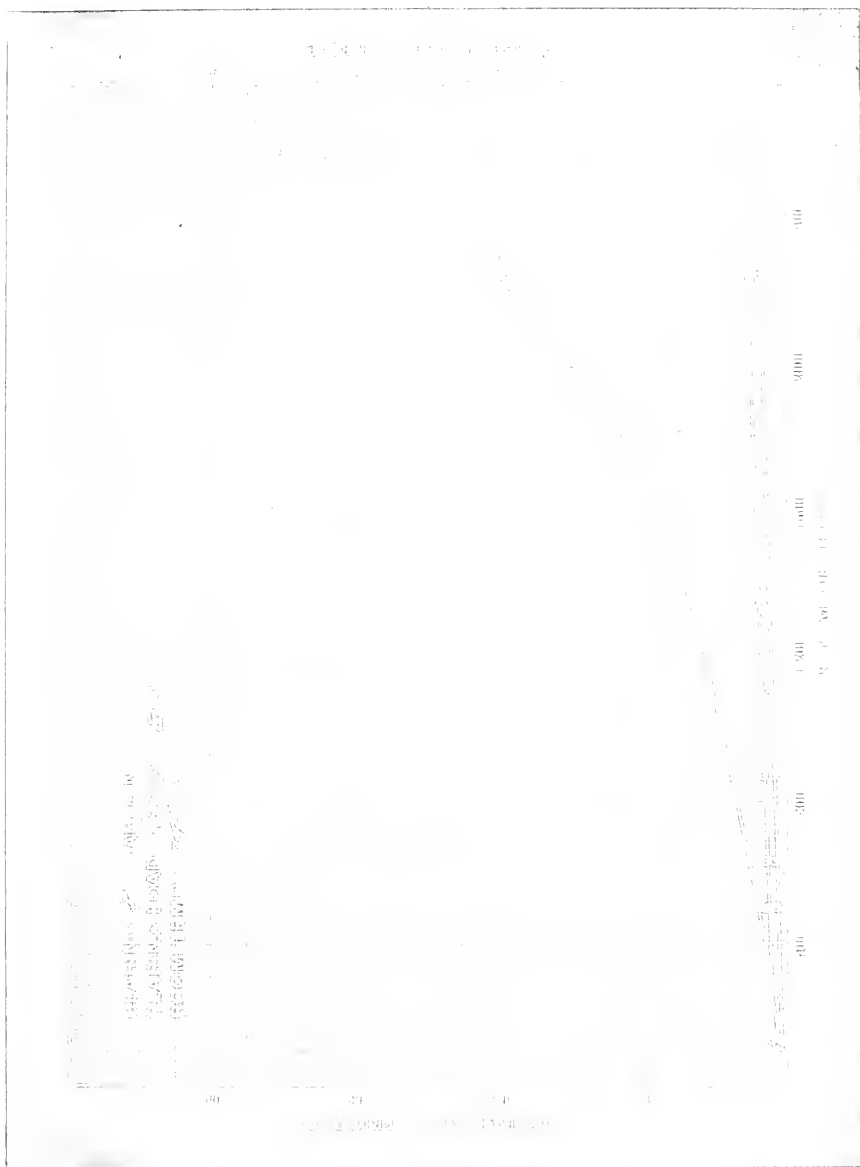
— — — — —

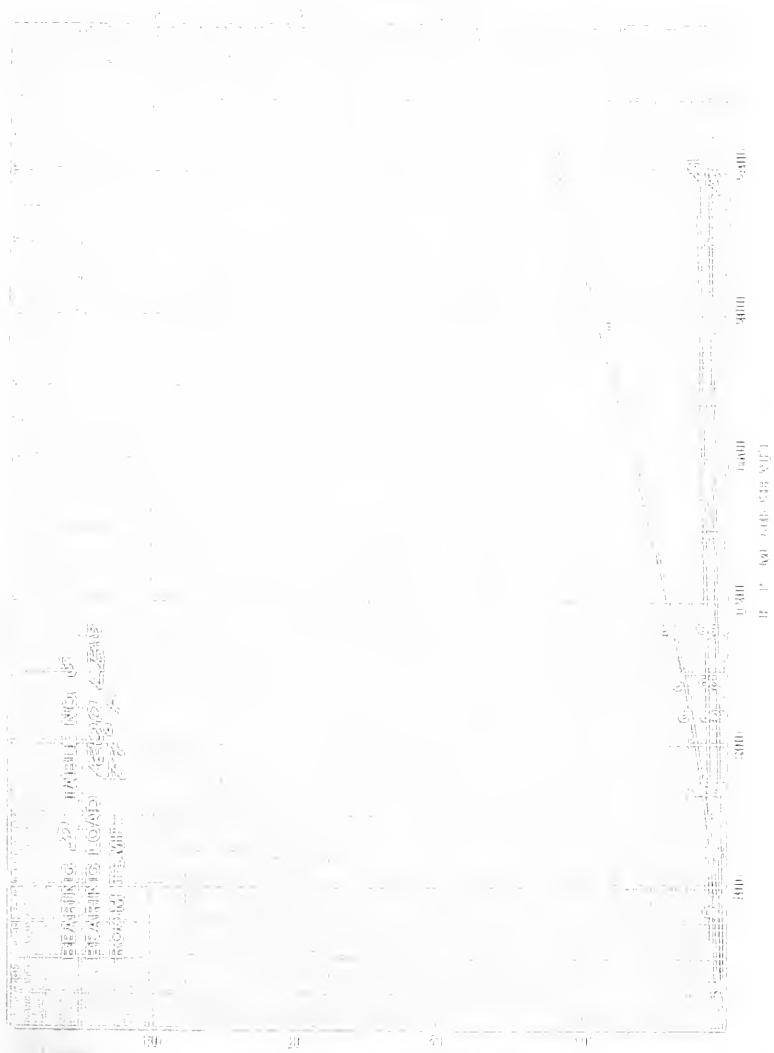
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日本大正十三年 二月 十日
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Figure 1. (a) Map of the study area.

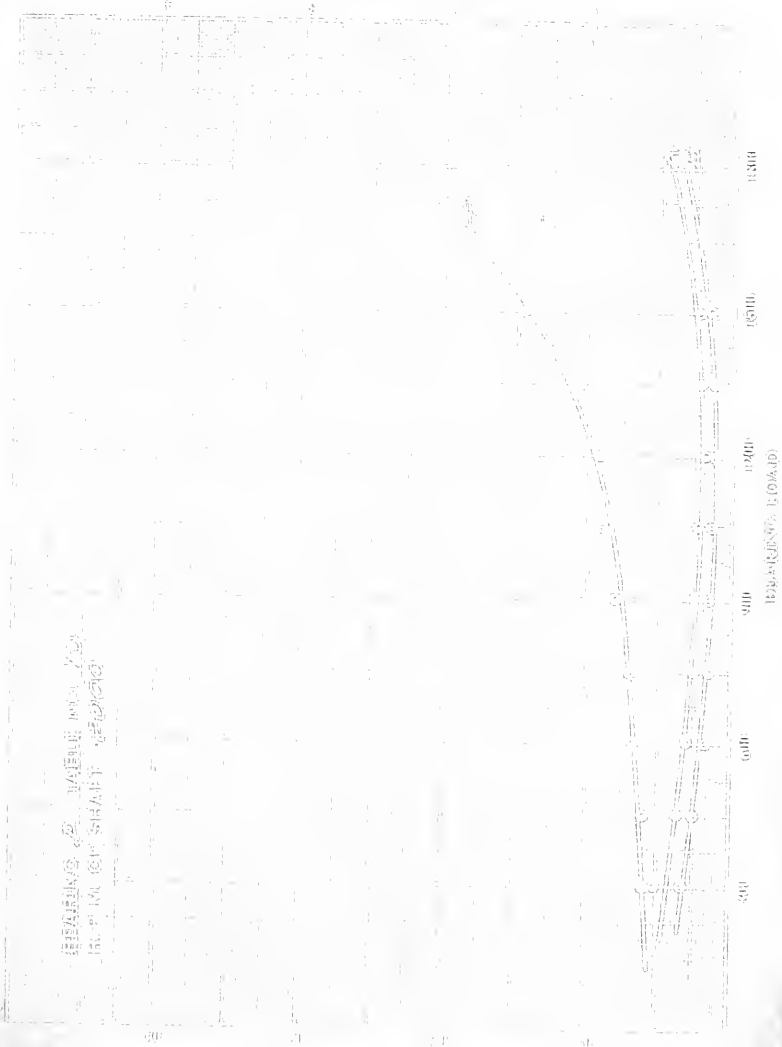


Figure 1. (b) Map of the study area.

10. 10. 1950. 10. 10. 1950.
10. 10. 1950. 10. 10. 1950.



3. 11. 1960. 11. 11. 1960.

REPORTING: 22. 11. 1960
IN: 11. 11. 1960

300

1500

1400

1000

600

400

12. 11. 1960. 1. 10. 1960

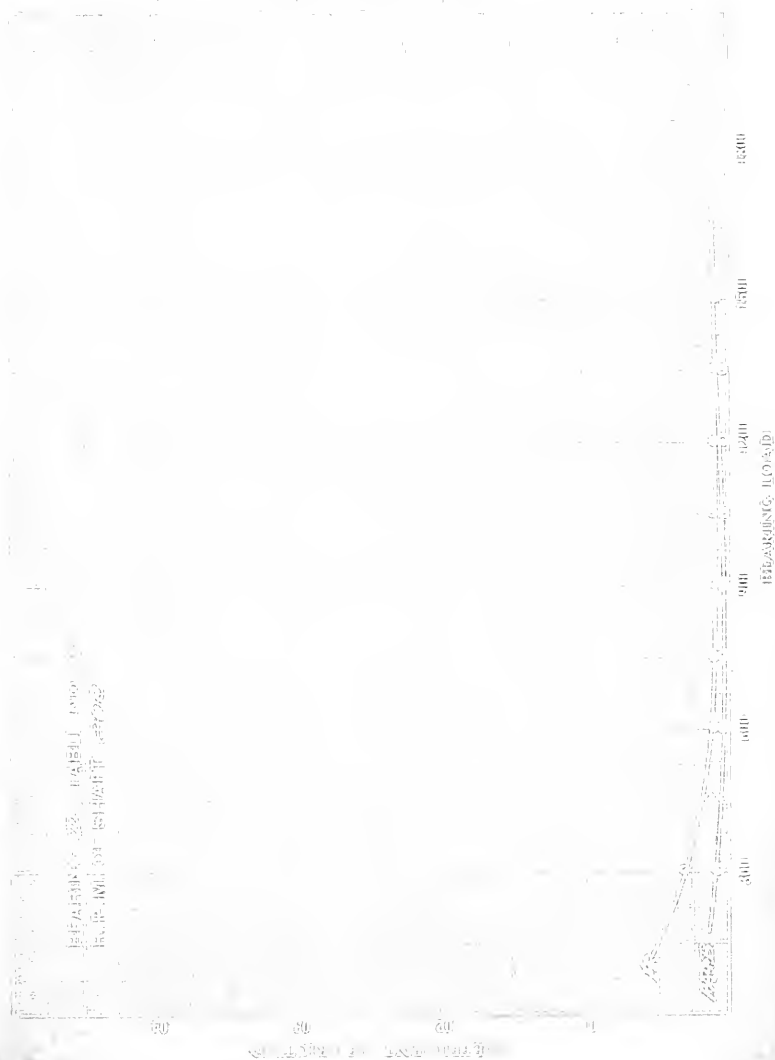
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BEARING "E"



Fig. 14

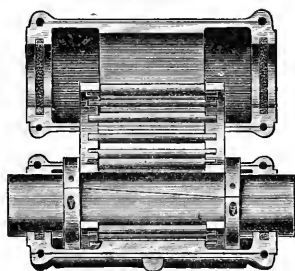


Fig. 15



BEARING "E"

Bearing "E", (Figures 14,15), is a roller bearing with a single roller structure, with all parts split so as to be able to apply the bearing to the shaft easily.

A split bushing or sleeve fits over the shaft and this is the raceway for the rolls. Two collars which clamp the split bushing to the shaft retain the roller structure, affording movable surfaces with which the ends of the roller structure come into contact. The collars do not touch the box, thereby, relieving the bearing from end thrust.

The rolls are held by a steel retainer and each retainer is split. A ground portion of the inside of the bearing box provides an outer raceway for the rolls. The grease is retained in the box by pieces of felt which fit into grooves in the ends of the bearing box.

The chief fault of this bearing is that when mounting the split bushing on the

shaft, it would never fit exactly around the circumference and consequently did not provide a perfectly cylindrical raceway for the rolls. The result of this, is, that there is a pounding up and down of the split retainer and an inability of the rolls to take their proper load. This caused a heating of the bearing and a comparatively high coefficient of friction.

During all runs, the felt oil retainers were removed as they were so tight against the shaft that they caused the bearing and shaft to heat up to a greater extent than was allowable, but, this fault could be easily overcome by the use of a better grade of felt and having a looser fit on the shaft.

While running under load, the bearing was quite noisy and prone to heat up to an alarming extent.

TABLES 1 - 13

OF

BEARING "E"

BEARING E

Table No. 1 Date July 21st, 1915.

Bearing Load, LBS. 1500 Time, beginning of run 8:58 A.M.

Room Temp.^o Fahr. 73 Time, end of run _____

Observers _____

NOTE:—All data average of four bearings.

[illegible]

Remarks:— Considerable vibration noted during run.

BEARING E

Table No. 2 Date July 21st, 1915.

Bearing Load, LBS. 1350 Time, beginning of run _____

Room Temp.° Fahr. 73 Time, end of run _____

Observers _____

NOTE:—All data average of four bearings.

[illegible]

Remarks:—

B E A R I N G E

Table No. 3 Date July 21st, 1915.
 Bearing Load, LBS. 1200 Time, beginning of run _____
 Room Temp. ° Fahr. 73 Time, end of run 9:33 A.M.
 Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE | | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|--------|-------|-------------------------|-------------------------|---------|
| | | Inch | Lbs. | | Shaft | Bearing |
| 0.69 | 618 | 21.70 | 0.213 | 0.0148 | 0.01130 | |
| 0.575 | 602 | 18.10 | 0.173 | 0.0124 | 0.00947 | |
| 0.48 | 536 | 15.10 | 0.129 | 0.0104 | 0.00794 | |
| 0.445 | 433 | 14.00 | 0.096 | 0.0096 | 0.00733 | |
| 0.425 | 401 | 13.40 | 0.085 | 0.0092 | 0.00703 | |
| 0.42 | 364 | 13.21 | 0.077 | 0.0091 | 0.00695 | |
| 0.43 | 284 | 13.52 | 0.061 | 0.0093 | 0.00710 | |
| 0.445 | 258 | 14.00 | 0.058 | 0.0096 | 0.00733 | |
| 0.46 | 200 | 14.48 | 0.046 | 0.0099 | 0.00755 | |
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Remarks:—

B E A R I N G E

Table No. 4 Date July 21st, 1915.
 Bearing Load, LBS. 1050 Time, beginning of run 9:35 A.M.
 Room Temp.° Fahr. 73 Time, end of run _____
 Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE
Inch Lbs. | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|---------------------|-------------------------|-------------------------|---------|
| | | | | Shaft | Bearing |
| 0.56 | 626 | 17.62 | 0.175 | 0.0138 | 0.01053 |
| 0.49 | 607 | 15.42 | 0.149 | 0.0121 | 0.00925 |
| 0.43 | 570 | 13.53 | 0.123 | 0.0106 | 0.00809 |
| 0.415 | 461 | 13.08 | 0.096 | 0.0102 | 0.00779 |
| 0.39 | 425 | 12.28 | 0.083 | 0.0096 | 0.00733 |
| 0.36 | 383 | 11.34 | 0.069 | 0.0089 | 0.00679 |
| 0.375 | 316 | 11.80 | 0.059 | 0.0092 | 0.00703 |
| 0.37 | 311 | 11.64 | 0.057 | 0.0091 | 0.00695 |
| 0.385 | 258 | 12.12 | 0.050 | 0.0095 | 0.00725 |
| 0.405 | 180 | 12.73 | 0.036 | 0.0100 | 0.00754 |
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Remarks:—

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B E A R I N G E

Table No. 5 Date July 21st, 1915.

Bearing Load, LBS. 900 Time, beginning of run _____

Room Temp. ° Fahr. 73 Time, end of run _____

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE
Inch Lbs. | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|---------------------|-------------------------|-------------------------|---------|
| | | | | Shaft | Bearing |
| 0.345 | 627 | 10.86 | 0.108 | 0.0099 | 0.00756 |
| 0.33 | 542 | 10.38 | 0.090 | 0.0095 | 0.00725 |
| 0.31 | 502 | 9.77 | 0.078 | 0.0089 | 0.00679 |
| 0.305 | 424 | 9.60 | 0.065 | 0.0086 | 0.00657 |
| 0.31 | 414 | 9.77 | 0.064 | 0.0089 | 0.00679 |
| 0.315 | 331 | 9.92 | 0.052 | 0.0091 | 0.00695 |
| 0.32 | 297 | 10.08 | 0.048 | 0.0092 | 0.00903 |
| 0.34 | 210 | 10.38 | 0.035 | 0.0095 | 0.00725 |
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Remarks:—

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B E A R I N G E

Table No. 6 Date July 21st, 1915.
 Bearing Load, LBS. 750 Time, beginning of run 10 A.M.
 Room Temp.° Fahr. 73 Time, end of run _____
 Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE | | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|--------|------|-------------------------|-------------------------|---------|
| | | Inch | Lbs. | | Shaft | Bearing |
| 0.315 | 670 | 9.92 | | 0.106 | 0.0109 | 0.00833 |
| 0.295 | 621 | 9.28 | | 0.092 | 0.0102 | 0.00778 |
| 0.275 | 538 | 8.67 | | 0.094 | 0.0095 | 0.00725 |
| 0.27 | 495 | 8.50 | | 0.067 | 0.0093 | 0.00710 |
| 0.26 | 385 | 8.18 | | 0.050 | 0.0090 | 0.00687 |
| 0.265 | 365 | 8.34 | | 0.048 | 0.0091 | 0.00695 |
| 0.27 | 304 | 8.50 | | 0.041 | 0.0093 | 0.00710 |
| 0.275 | 288 | 8.66 | | 0.040 | 0.0095 | 0.00625 |
| 0.28 | 212 | 8.82 | | 0.030 | 0.0097 | 0.00741 |
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Remarks:—

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B E A R I N G E

Table No. 7 Date July 21st, 1915.

Bearing Load, LBS. 600 Time, beginning of run _____

Room Temp.° Fahr. 73 Time, end of run _____

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE | | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|--------|------|-------------------------|-------------------------|---------|
| | | Inch | Lbs. | | Shaft | Bearing |
| 0.265 | 645 | 8.34 | | 0.086 | 0.0114 | 0.0087 |
| 0.26 | 596 | 8.18 | | 0.078 | 0.0112 | 0.0086 |
| 0.24 | 525 | 7.57 | | 0.063 | 0.0103 | 0.00786 |
| 0.23 | 441 | 7.25 | | 0.051 | 0.0099 | 0.00756 |
| 0.22 | 388 | 6.94 | | 0.043 | 0.0095 | 0.00725 |
| 0.21 | 292 | 6.63 | | 0.031 | 0.0091 | 0.00695 |
| 0.215 | 266 | 6.78 | | 0.029 | 0.0093 | 0.00710 |
| 0.23 | 177 | 7.25 | | 0.020 | 0.0099 | 0.00756 |
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Remarks:—

B E A R I N G E

Table No. 8 Date July 21st, 1915.

Bearing Load, LBS. 450 Time, beginning of run _____

Room Temp.° Fahr. 73 Time, end of run _____

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE | | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|--------|------|-------------------------|-------------------------|---------|
| | | Inch | Lbs. | | Shaft | Bearing |
| 0.215 | 659 | 6.78 | | 0.071 | 0.0124 | 0.00946 |
| 0.205 | 558 | 6.48 | | 0.057 | 0.0118 | 0.00901 |
| 0.195 | 476 | 6.15 | | 0.046 | 0.0113 | 0.00862 |
| 0.19 | 445 | 5.99 | | 0.042 | 0.0109 | 0.00832 |
| 0.18 | 365 | 5.68 | | 0.033 | 0.0104 | 0.00794 |
| 0.17 | 320 | 5.36 | | 0.027 | 0.0098 | 0.00748 |
| 0.16 | 260 | 5.04 | | 0.021 | 0.0092 | 0.00703 |
| 0.17 | 189 | 5.36 | | 0.016 | 0.0098 | 0.00748 |
| 0.175 | 149 | 5.52 | | 0.013 | 0.0101 | 0.00771 |
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Remarks:—

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B E A R I N G E

Table No. 9 Date July 21st, 1915.

Bearing Load, LBS. 300 Time, beginning of run _____

Room Temp.° Fahr. 73 Time, end of run _____

Observers _____

NOTE:—All data average of four bearings.

| POUNDS
at 31½ in. radius | R. P. M. | TORQUE | | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------------------|----------|--------|------|-------------------------|-------------------------|---------|
| | | Inch | Lbs. | | Shaft | Bearing |
| 0.20 | 671 | 6.31 | | 0.067 | 0.0173 | 0.01320 |
| 0.19 | 632 | 5.98 | | 0.060 | 0.0164 | 0.01251 |
| 0.18 | 591 | 5.68 | | 0.053 | 0.0155 | 0.01182 |
| 0.165 | 529 | 5.20 | | 0.044 | 0.0142 | 0.01083 |
| 0.155 | 411 | 4.88 | | 0.032 | 0.0134 | 0.01023 |
| 0.145 | 377 | 4.57 | | 0.027 | 0.0125 | 0.00953 |
| 0.14 | 318 | 4.42 | | 0.022 | 0.0121 | 0.00923 |
| 0.13 | 247 | 4.10 | | 0.016 | 0.0112 | 0.00855 |
| 0.13 | 202 | 4.10 | | 0.013 | 0.0112 | 0.00855 |
| 0.14 | 128 | 4.26 | | 0.009 | 0.0117 | 0.00893 |
| 0.145 | 66 | 4.41 | | 0.005 | 0.0121 | 0.00923 |
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Remarks:—

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DATA INTERPOLATED
FROM TABLES 1—9

Bearing E

R. P. M. of Shaft 600

Table No. 10

| Bearing
Load | Horse Power
to Drive | COEFFICIENT OF FRICTION | |
|-----------------|-------------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | | 0.016 | 0.014 |
| 1350 | 0.245 | 0.016 | 0.014 |
| 1200 | 0.2 | 0.014 | 0.0105 |
| 1050 | 0.14 | 0.0125 | 0.0096 |
| 900 | 0.10 | 0.0095 | 0.0075 |
| 750 | 0.09 | 0.0101 | 0.008 |
| 600 | 0.077 | 0.0103 | 0.0082 |
| 450 | 0.057 | 0.0157 | 0.012 |
| 300 | 0.063 | 0.0137 | 0.0092 |
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Remarks:—

DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ E _____

R. P. M. of Shaft 400 _____

Table No. 11 _____

| Bearing Load | Horse Power to Drive | COEFFICIENT OF FRICTION | |
|--------------|----------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.12 | 0.0107 | 0.008 |
| 1350 | 0.105 | 0.0098 | 0.0075 |
| 1200 | 0.088 | 0.0095 | 0.0072 |
| 1050 | 0.075 | 0.0092 | 0.0070 |
| 900 | 0.058 | 0.0088 | 0.0068 |
| 750 | 0.052 | 0.0095 | 0.0072 |
| 600 | 0.05 | 0.0095 | 0.0077 |
| 450 | 0.03 | 0.0127 | 0.0096 |
| 300 | 0.04 | 0.0105 | 0.008 |
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Remarks:—

DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ E. _____

R. P. M. of Shaft _____ 200 _____

Table No. 12 _____

| Bearing Load | Horse Power to Drive | COEFFICIENT OF FRICTION | |
|--------------|----------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.06 | 0.01 | 0.0079 |
| 1350 | 0.05 | 0.009 | 0.007 |
| 1200 | 0.045 | 0.0095 | 0.0075 |
| 1050 | 0.04 | 0.0097 | 0.0075 |
| 900 | 0.033 | 0.0095 | 0.0075 |
| 750 | 0.03 | 0.0098 | 0.0075 |
| 600 | 0.025 | 0.0097 | 0.008 |
| 450 | 0.01 | 0.0115 | 0.0088 |
| 300 | 0.016 | 0.0098 | 0.0074 |
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Remarks:—

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DATA INTERPOLATED
FROM TABLES 1—9

Bearing _____ E _____

R. P. M. of Shaft _____ 100 _____

Table No. 13 _____

| Bearing Load | Horse Power to Drive | COEFFICIENT OF FRICTION | |
|--------------|----------------------|-------------------------|---------|
| | | Shaft | Bearing |
| 1500 | 0.046 | 0.0105 | 0.0085 |
| 1350 | 0.036 | 0.0095 | 0.0076 |
| 1200 | 0.035 | 0.0106 | 0.0089 |
| 1050 | 0.023 | 0.011 | 0.0085 |
| 900 | 0.026 | 0.011 | 0.0089 |
| 750 | 0.025 | 0.0105 | 0.0082 |
| 600 | 0.01 | 0.0102 | 0.0085 |
| 450 | 0.005 | 0.012 | 0.009 |
| 300 | 0.007 | 0.0097 | 0.0073 |
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Remarks:—

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| 1 | 2 | 3 |
| 4 | 5 | 6 |
| 7 | 8 | 9 |
| 10 | 11 | 12 |
| 13 | 14 | 15 |
| 16 | 17 | 18 |
| 19 | 20 | 21 |
| 22 | 23 | 24 |
| 25 | 26 | 27 |
| 28 | 29 | 30 |
| 31 | 32 | 33 |
| 34 | 35 | 36 |
| 37 | 38 | 39 |
| 40 | 41 | 42 |
| 43 | 44 | 45 |
| 46 | 47 | 48 |
| 49 | 50 | 51 |
| 52 | 53 | 54 |
| 55 | 56 | 57 |
| 58 | 59 | 60 |
| 61 | 62 | 63 |
| 64 | 65 | 66 |
| 67 | 68 | 69 |
| 70 | 71 | 72 |
| 73 | 74 | 75 |
| 76 | 77 | 78 |
| 79 | 80 | 81 |
| 82 | 83 | 84 |
| 85 | 86 | 87 |
| 88 | 89 | 90 |
| 91 | 92 | 93 |
| 94 | 95 | 96 |
| 97 | 98 | 99 |
| 100 | 101 | 102 |
| 103 | 104 | 105 |
| 106 | 107 | 108 |
| 109 | 110 | 111 |
| 112 | 113 | 114 |
| 115 | 116 | 117 |
| 118 | 119 | 120 |
| 121 | 122 | 123 |
| 124 | 125 | 126 |
| 127 | 128 | 129 |
| 130 | 131 | 132 |
| 133 | 134 | 135 |
| 136 | 137 | 138 |
| 139 | 140 | 141 |
| 142 | 143 | 144 |
| 145 | 146 | 147 |
| 148 | 149 | 150 |
| 151 | 152 | 153 |
| 154 | 155 | 156 |
| 157 | 158 | 159 |
| 160 | 161 | 162 |
| 163 | 164 | 165 |
| 166 | 167 | 168 |
| 169 | 170 | 171 |
| 172 | 173 | 174 |
| 175 | 176 | 177 |
| 178 | 179 | 180 |
| 181 | 182 | 183 |
| 184 | 185 | 186 |
| 187 | 188 | 189 |
| 190 | 191 | 192 |
| 193 | 194 | 195 |
| 196 | 197 | 198 |
| 199 | 200 | 201 |
| 202 | 203 | 204 |
| 205 | 206 | 207 |
| 208 | 209 | 210 |
| 211 | 212 | 213 |
| 214 | 215 | 216 |
| 217 | 218 | 219 |
| 220 | 221 | 222 |
| 223 | 224 | 225 |
| 226 | 227 | 228 |
| 229 | 230 | 231 |
| 232 | 233 | 234 |
| 235 | 236 | 237 |
| 238 | 239 | 240 |
| 241 | 242 | 243 |
| 244 | 245 | 246 |
| 247 | 248 | 249 |
| 250 | 251 | 252 |
| 253 | 254 | 255 |
| 256 | 257 | 258 |
| 259 | 260 | 261 |
| 262 | 263 | 264 |
| 265 | 266 | 267 |
| 268 | 269 | 270 |
| 271 | 272 | 273 |
| 274 | 275 | 276 |
| 277 | 278 | 279 |
| 280 | 281 | 282 |
| 283 | 284 | 285 |
| 286 | 287 | 288 |
| 289 | 290 | 291 |
| 292 | 293 | 294 |
| 295 | 296 | 297 |
| 298 | 299 | 300 |
| 301 | 302 | 303 |
| 304 | 305 | 306 |
| 307 | 308 | 309 |
| 310 | 311 | 312 |
| 313 | 314 | 315 |
| 316 | 317 | 318 |
| 319 | 320 | 321 |
| 322 | 323 | 324 |
| 325 | 326 | 327 |
| 328 | 329 | 330 |
| 331 | 332 | 333 |
| 334 | 335 | 336 |
| 337 | 338 | 339 |
| 340 | 341 | 342 |
| 343 | 344 | 345 |
| 346 | 347 | 348 |
| 349 | 350 | 351 |
| 352 | 353 | 354 |
| 355 | 356 | 357 |
| 358 | 359 | 360 |
| 361 | 362 | 363 |
| 364 | 365 | 366 |
| 367 | 368 | 369 |
| 370 | 371 | 372 |
| 373 | 374 | 375 |
| 376 | 377 | 378 |
| 379 | 380 | 381 |
| 382 | 383 | 384 |
| 385 | 386 | 387 |
| 388 | 389 | 390 |
| 391 | 392 | 393 |
| 394 | 395 | 396 |
| 397 | 398 | 399 |
| 400 | 401 | 402 |
| 403 | 404 | 405 |
| 406 | 407 | 408 |
| 409 | 410 | 411 |
| 412 | 413 | 414 |
| 415 | 416 | 417 |
| 418 | 419 | 420 |
| 421 | 422 | 423 |
| 424 | 425 | 426 |
| 427 | 428 | 429 |
| 430 | 431 | 432 |
| 433 | 434 | 435 |
| 436 | 437 | 438 |
| 439 | 440 | 441 |
| 442 | 443 | 444 |
| 445 | 446 | 447 |
| 448 | 449 | 450 |
| 451 | 452 | 453 |
| 454 | 455 | 456 |
| 457 | 458 | 459 |
| 460 | 461 | 462 |
| 463 | 464 | 465 |
| 466 | 467 | 468 |
| 469 | 470 | 471 |
| 472 | 473 | 474 |
| 475 | 476 | 477 |
| 478 | 479 | 480 |
| 481 | 482 | 483 |
| 484 | 485 | 486 |
| 487 | 488 | 489 |
| 490 | 491 | 492 |
| 493 | 494 | 495 |
| 496 | 497 | 498 |
| 499 | 500 | 501 |
| 502 | 503 | 504 |
| 505 | 506 | 507 |
| 508 | 509 | 510 |
| 511 | 512 | 513 |
| 514 | 515 | 516 |
| 517 | 518 | 519 |
| 520 | 521 | 522 |
| 523 | 524 | 525 |
| 526 | 527 | 528 |
| 529 | 530 | 531 |
| 532 | 533 | 534 |
| 535 | 536 | 537 |
| 538 | 539 | 540 |
| 541 | 542 | 543 |
| 544 | 545 | 546 |
| 547 | 548 | 549 |
| 550 | 551 | 552 |
| 553 | 554 | 555 |
| 556 | 557 | 558 |
| 559 | 560 | 561 |
| 562 | 563 | 564 |
| 565 | 566 | 567 |
| 568 | 569 | 570 |
| 571 | 572 | 573 |
| 574 | 575 | 576 |
| 577 | 578 | 579 |
| 580 | 581 | 582 |
| 583 | 584 | 585 |
| 586 | 587 | 588 |
| 589 | 590 | 591 |
| 592 | 593 | 594 |
| 595 | 596 | 597 |
| 598 | 599 | 600 |
| 601 | 602 | 603 |
| 604 | 605 | 606 |
| 607 | 608 | 609 |
| 610 | 611 | 612 |
| 613 | 614 | 615 |
| 616 | 617 | 618 |
| 619 | 620 | 621 |
| 622 | 623 | 624 |
| 625 | 626 | 627 |
| 628 | 629 | 630 |
| 631 | 632 | 633 |
| 634 | 635 | 636 |
| 637 | 638 | 639 |
| 640 | 641 | 642 |
| 643 | 644 | 645 |
| 646 | 647 | 648 |
| 649 | 650 | 651 |
| 652 | 653 | 654 |
| 655 | 656 | 657 |
| 658 | 659 | 660 |
| 661 | 662 | 663 |
| 664 | 665 | 666 |
| 667 | 668 | 669 |
| 670 | 671 | 672 |
| 673 | 674 | 675 |
| 676 | 677 | 678 |
| 679 | 680 | 681 |
| 682 | 683 | 684 |
| 685 | 686 | 687 |
| 688 | 689 | 690 |
| 691 | 692 | 693 |
| 694 | 695 | 696 |
| 697 | 698 | 699 |
| 700 | 701 | 702 |
| 703 | 704 | 705 |
| 706 | 707 | 708 |
| 709 | 710 | 711 |
| 712 | 713 | 714 |
| 715 | 716 | 717 |
| 718 | 719 | 720 |
| 721 | 722 | 723 |
| 724 | 725 | 726 |
| 727 | 728 | 729 |
| 730 | 731 | 732 |
| 733 | 734 | 735 |
| 736 | 737 | 738 |
| 739 | 740 | 741 |
| 742 | 743 | 744 |
| 745 | 746 | 747 |
| 748 | 749 | 750 |
| 751 | 752 | 753 |
| 754 | 755 | 756 |
| 757 | 758 | 759 |
| 760 | 761 | 762 |
| 763 | 764 | 765 |
| 766 | 767 | 768 |
| 769 | 770 | 771 |
| 772 | 773 | 774 |
| 775 | 776 | 777 |
| 778 | 779 | 780 |
| 781 | 782 | 783 |
| 784 | 785 | 786 |
| 787 | 788 | 789 |
| 790 | 791 | 792 |
| 793 | 794 | 795 |
| 796 | 797 | 798 |
| 799 | 800 | 801 |
| 802 | 803 | 804 |
| 805 | 806 | 807 |
| 808 | 809 | 810 |
| 811 | 812 | 813 |
| 814 | 815 | 816 |
| 817 | 818 | 819 |
| 820 | 821 | 822 |
| 823 | 824 | 825 |
| 826 | 827 | 828 |
| 829 | 830 | 831 |
| 832 | 833 | 834 |
| 835 | 836 | 837 |
| 838 | 839 | 840 |
| 841 | 842 | 843 |
| 844 | 845 | 846 |
| 847 | 848 | 849 |
| 850 | 851 | 852 |
| 853 | 854 | 855 |
| 856 | 857 | 858 |
| 859 | 860 | 861 |
| 862 | 863 | 864 |
| 865 | 866 | 867 |
| 868 | 869 | 870 |
| 871 | 872 | 873 |
| 874 | 875 | 876 |
| 877 | 878 | 879 |
| 880 | 881 | 882 |
| 883 | 884 | 885 |
| 886 | 887 | 888 |
| 889 | 890 | 891 |
| 892 | 893 | 894 |
| 895 | 896 | 897 |
| 898 | 899 | 900 |
| 901 | 902 | 903 |
| 904 | 905 | 906 |
| 907 | 908 | 909 |
| 910 | 911 | 912 |
| 913 | 914 | 915 |
| 916 | 917 | 918 |
| 919 | 920 | 921 |
| 922 | 923 | 924 |
| 925 | 926 | 927 |
| 928 | 929 | 930 |
| 931 | 932 | 933 |
| 934 | 935 | 936 |
| 937 | 938 | 939 |
| 940 | 941 | 942 |
| 943 | 944 | 945 |
| 946 | 947 | 948 |
| 949 | 950 | 951 |
| 952 | 953 | 954 |
| 955 | 956 | 957 |
| 958 | 959 | 960 |
| 961 | 962 | 963 |
| 964 | 965 | 966 |
| 967 | 968 | 969 |
| 970 | 971 | 972 |
| 973 | 974 | 975 |
| 976 | 977 | 978 |
| 979 | 980 | 981 |
| 982 | 983 | 984 |
| 985 | 986 | 987 |
| 988 | 989 | 990 |
| 991 | 992 | 993 |
| 994 | 995 | 996 |
| 997 | 998 | 999 |
| 1000 | 1001 | 1002 |
| 1003 | 1004 | 1005 |
| 1006 | 1007 | 1008 |
| 1009 | 1010 | 1011 |
| 1012 | 1013 | 1014 |
| 1015 | 1016 | 1017 |
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| 1021 | 1022 | 1023 |
| 1024 | 1025 | 1026 |
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| 1030 | 1031 | 1032 |
| 1033 | 1034 | 1035 |
| 1036 | 1037 | 1038 |
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| 1075 | 1076 | 1077 |
| 1078 | 1079 | 1080 |
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| 1093 | 1094 | 1095 |
| 1096 | 1097 | 1098 |
| 1099 | 1100 | 1101 |
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| 1108 | 1109 | 1110 |
| 1111 | 1112 | 1113 |
| 1114 | 1115 | 1116 |
| 1117 | 1118 | 1119 |
| 1120 | 1121 | 1122 |
| 1123 | 1124 | 1125 |
| 1126 | 1127 | 1128 |
| 1129 | 1130 | 1131 |
| 1132 | 1133 | 1134 |
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| 1147 | 1148 | 1149 |
| 1150 | 1151 | 1152 |
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| 1156 | 1157 | 1158 |
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| 1171 | 1172 | 1173 |
| 1174 | 1175 | 1176 |
| 1177 | 1178 | 1179 |
| 1180 | 1181 | 1182 |
| 1183 | 1184 | 1185 |
| 1186 | 1187 | 1188 |
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| 1198 | 1199 | 1200 |
| 1201 | 1202 | 1203 |
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| 1219 | 1220 | 1221 |
| 1222 | 1223 | 1224 |

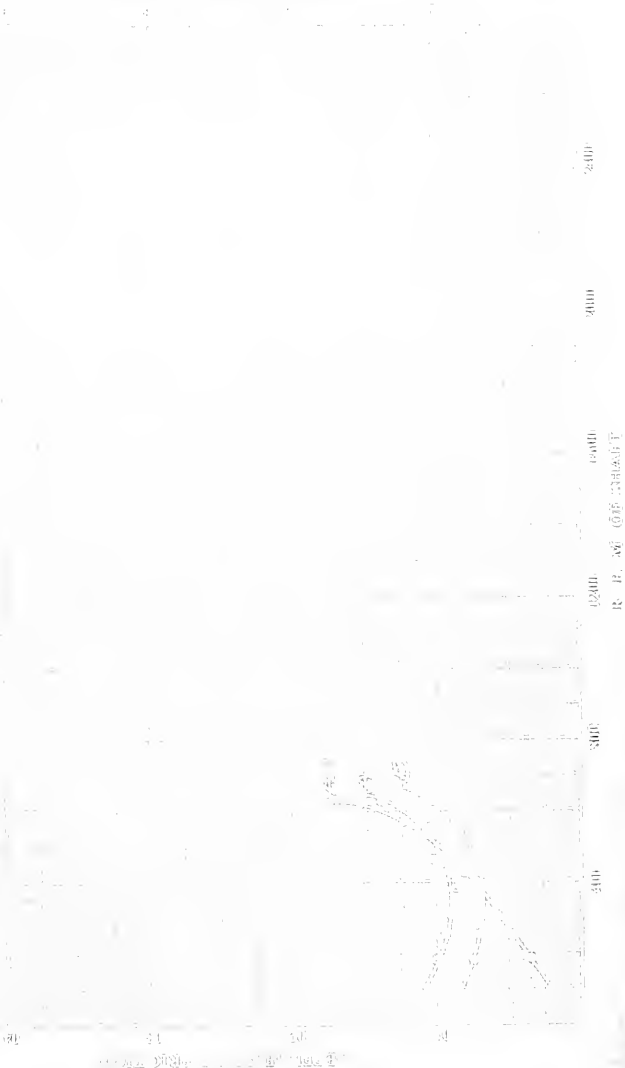
CURVES PLOTTED FROM
TABLES 1 - 13
OF
BEARING "E"

6108

| Year | Population | Population | Population | Population | Population |
|------|------------|------------|------------|------------|------------|
| 1990 | 100 | 100 | 100 | 100 | 100 |
| 1991 | 100 | 100 | 100 | 100 | 100 |
| 1992 | 100 | 100 | 100 | 100 | 100 |
| 1993 | 100 | 100 | 100 | 100 | 100 |
| 1994 | 100 | 100 | 100 | 100 | 100 |
| 1995 | 100 | 100 | 100 | 100 | 100 |
| 1996 | 100 | 100 | 100 | 100 | 100 |
| 1997 | 100 | 100 | 100 | 100 | 100 |
| 1998 | 100 | 100 | 100 | 100 | 100 |
| 1999 | 100 | 100 | 100 | 100 | 100 |
| 2000 | 100 | 100 | 100 | 100 | 100 |
| 2001 | 100 | 100 | 100 | 100 | 100 |
| 2002 | 100 | 100 | 100 | 100 | 100 |
| 2003 | 100 | 100 | 100 | 100 | 100 |
| 2004 | 100 | 100 | 100 | 100 | 100 |
| 2005 | 100 | 100 | 100 | 100 | 100 |
| 2006 | 100 | 100 | 100 | 100 | 100 |
| 2007 | 100 | 100 | 100 | 100 | 100 |
| 2008 | 100 | 100 | 100 | 100 | 100 |
| 2009 | 100 | 100 | 100 | 100 | 100 |
| 2010 | 100 | 100 | 100 | 100 | 100 |
| 2011 | 100 | 100 | 100 | 100 | 100 |
| 2012 | 100 | 100 | 100 | 100 | 100 |
| 2013 | 100 | 100 | 100 | 100 | 100 |
| 2014 | 100 | 100 | 100 | 100 | 100 |
| 2015 | 100 | 100 | 100 | 100 | 100 |
| 2016 | 100 | 100 | 100 | 100 | 100 |
| 2017 | 100 | 100 | 100 | 100 | 100 |
| 2018 | 100 | 100 | 100 | 100 | 100 |
| 2019 | 100 | 100 | 100 | 100 | 100 |
| 2020 | 100 | 100 | 100 | 100 | 100 |
| 2021 | 100 | 100 | 100 | 100 | 100 |
| 2022 | 100 | 100 | 100 | 100 | 100 |
| 2023 | 100 | 100 | 100 | 100 | 100 |
| 2024 | 100 | 100 | 100 | 100 | 100 |
| 2025 | 100 | 100 | 100 | 100 | 100 |
| 2026 | 100 | 100 | 100 | 100 | 100 |
| 2027 | 100 | 100 | 100 | 100 | 100 |
| 2028 | 100 | 100 | 100 | 100 | 100 |
| 2029 | 100 | 100 | 100 | 100 | 100 |
| 2030 | 100 | 100 | 100 | 100 | 100 |
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| 2032 | 100 | 100 | 100 | 100 | 100 |
| 2033 | 100 | 100 | 100 | 100 | 100 |
| 2034 | 100 | 100 | 100 | 100 | 100 |
| 2035 | 100 | 100 | 100 | 100 | 100 |
| 2036 | 100 | 100 | 100 | 100 | 100 |
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| 2039 | 100 | 100 | 100 | 100 | 100 |
| 2040 | 100 | 100 | 100 | 100 | 100 |
| 2041 | 100 | 100 | 100 | 100 | 100 |
| 2042 | 100 | 100 | 100 | 100 | 100 |
| 2043 | 100 | 100 | 100 | 100 | 100 |
| 2044 | 100 | 100 | 100 | 100 | 100 |
| 2045 | 100 | 100 | 100 | 100 | 100 |
| 2046 | 100 | 100 | 100 | 100 | 100 |
| 2047 | 100 | 100 | 100 | 100 | 100 |
| 2048 | 100 | 100 | 100 | 100 | 100 |
| 2049 | 100 | 100 | 100 | 100 | 100 |
| 2050 | 100 | 100 | 100 | 100 | 100 |
| 2051 | 100 | 100 | 100 | 100 | 100 |
| 2052 | 100 | 100 | 100 | 100 | 100 |
| 2053 | 100 | 100 | 100 | 100 | 100 |
| 2054 | 100 | 100 | 100 | 100 | 100 |

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REPORTING TABLE NO. 2
 BEARING LOAD: 10000 LBS.
 PROGRAM TEMPERATURE: 225 °F



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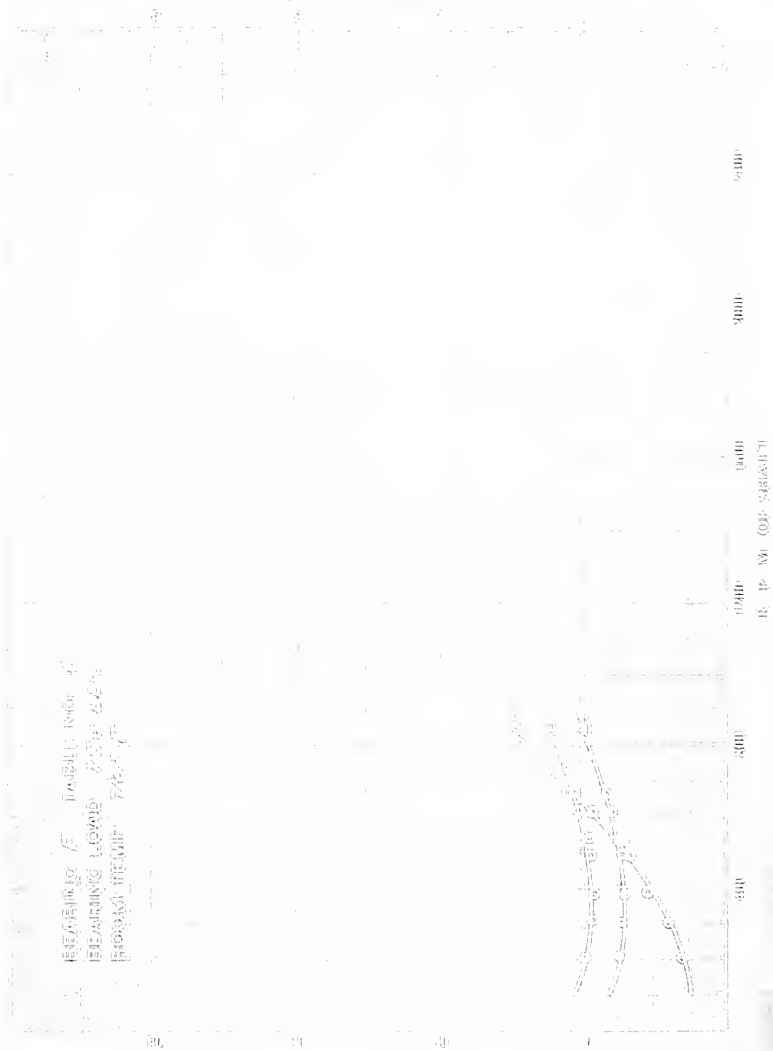
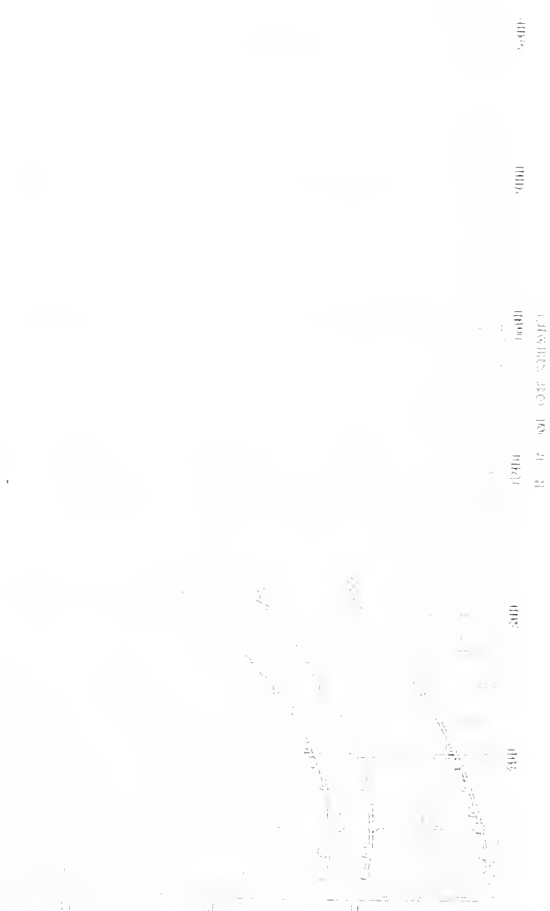


Fig. 1. Dependence of the dielectric constant ϵ' and the dielectric loss ϵ'' on the frequency ν for the polymer film.



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$$\frac{d}{dt} \left(\frac{1}{2} \dot{q}^2 + \frac{1}{2} \dot{\theta}^2 \right) = \frac{d}{dt} \left(\frac{1}{2} \dot{q}^2 + \frac{1}{2} \dot{\theta}^2 \right) = \frac{d}{dt} \left(\frac{1}{2} \dot{q}^2 + \frac{1}{2} \dot{\theta}^2 \right)$$
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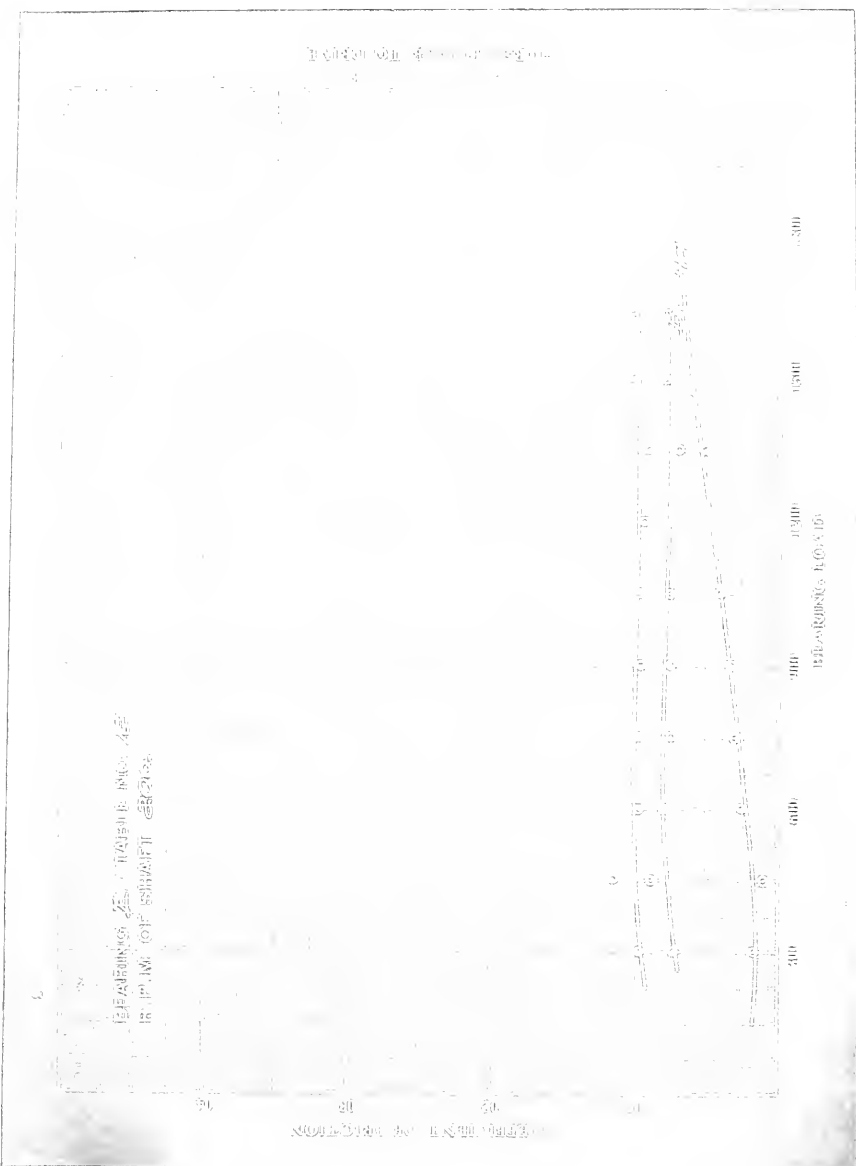
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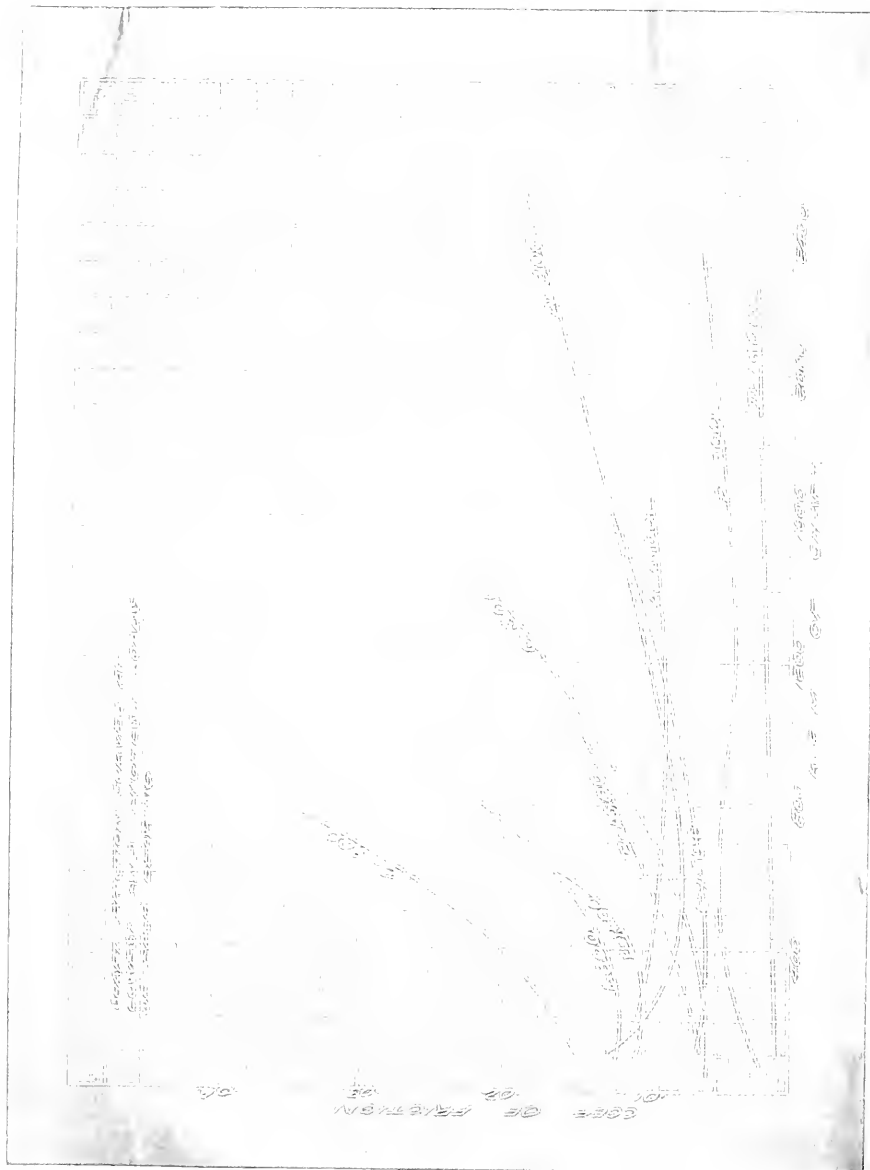
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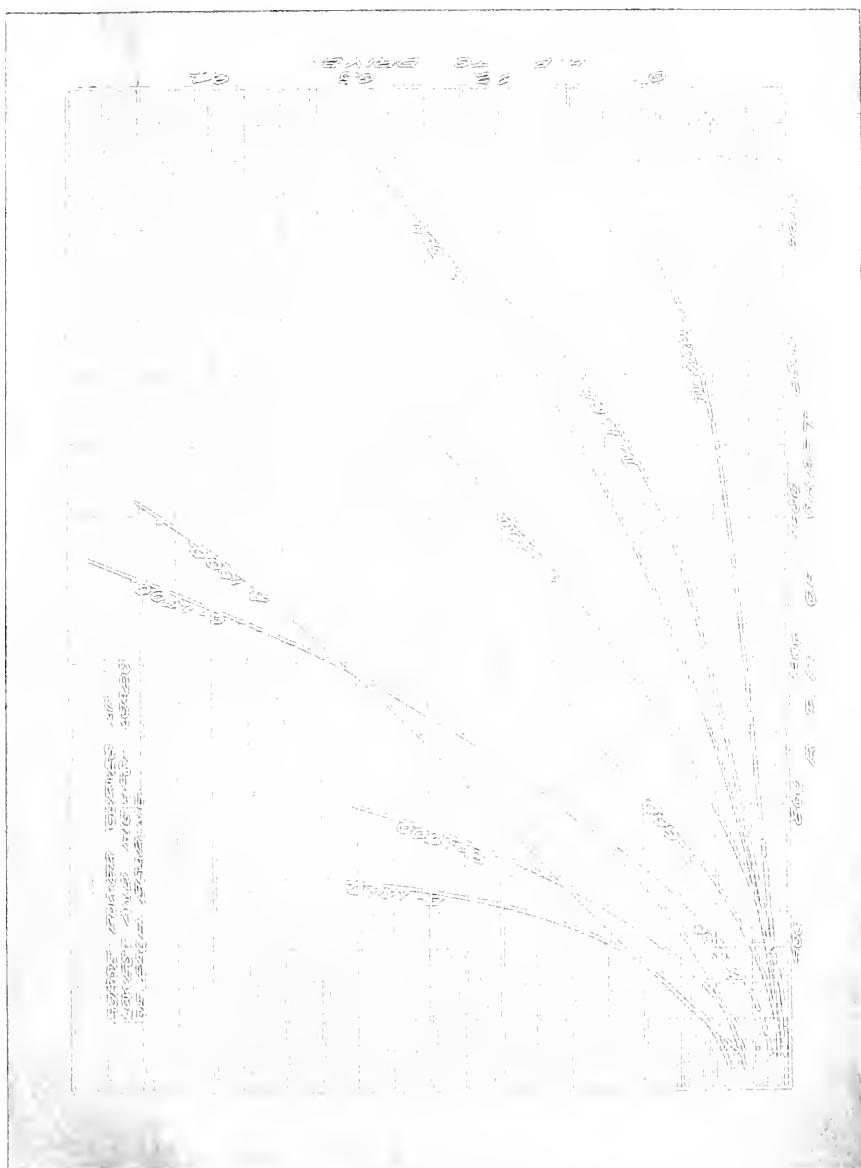
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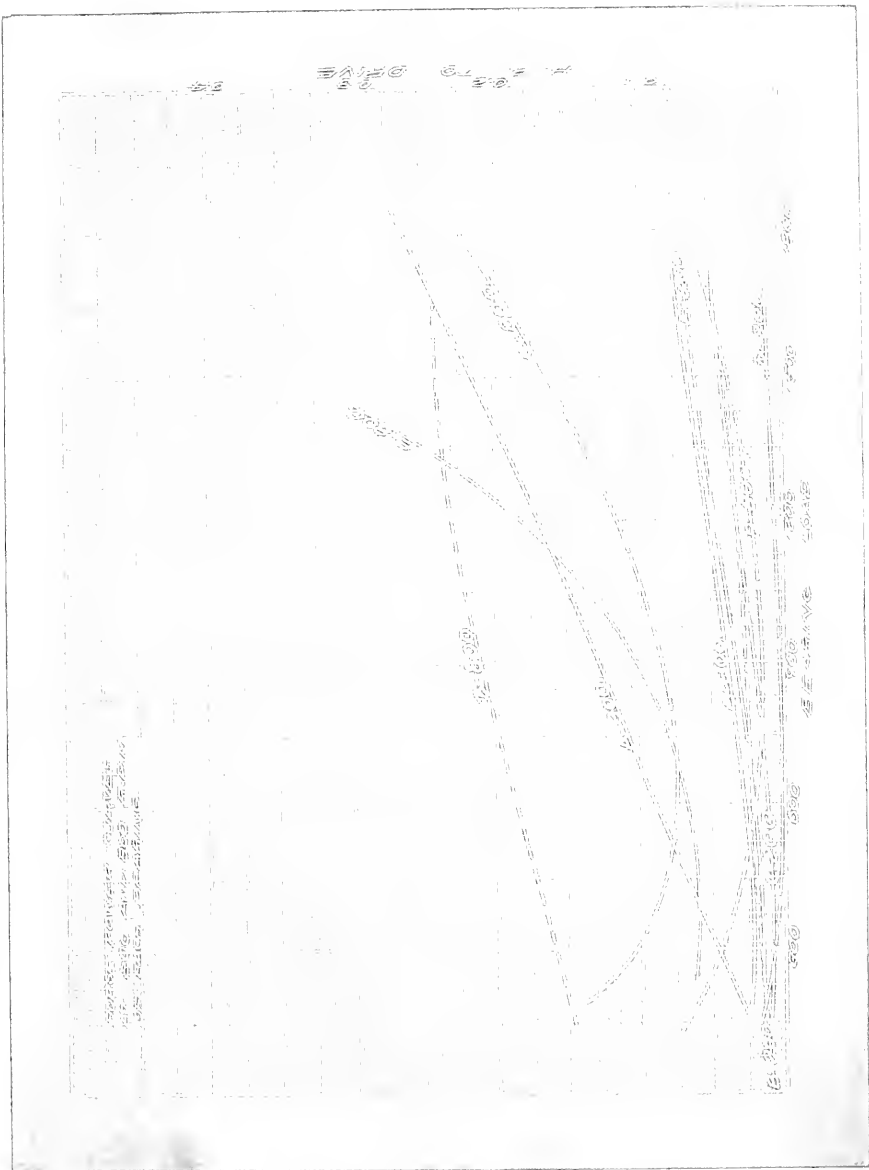
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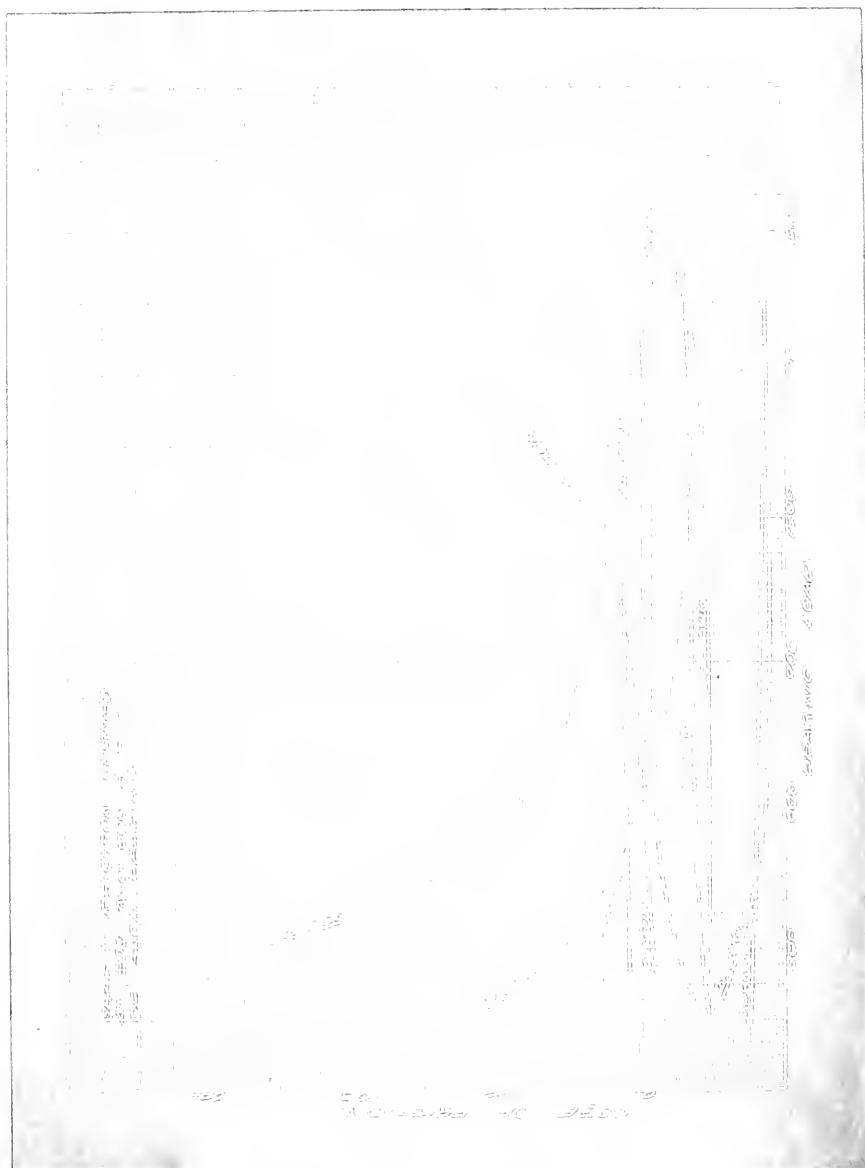


MAXIMUM AND MINIMUM
CURVES FOR
ALL BEARINGS











DISCUSSION OF RESULTS

DISCUSSION OF RESULTS

The first set of curves, plotted from tables 1 to 9, are those whose values are taken directly from the results of the test. Each sheet shows the curves for coefficients of friction and horse power to drive as compared to the speed of the shaft at some particular load.

The second set of curves, tables 10 to 16, were interpolated from the first set. The speed on each sheet being constant and the points plotted against a varying bearing load.

The third set is a résumé of the first set showing the maximum and minimum curves of the first set for each bearing.

The fourth set is a résumé of the second set, showing maximum and minimum curves for each bearing.

In all cases each curve is plainly marked with the bearing initial.

It will be seen from the sheet showing the maximum and minimum curves for each



Bearing plotted against the speed of the shaft that in every case, the coefficient of friction decreases as the load increases and that the coefficient of friction increases as the speed increases.

This sheet shows that Bearing "D", the ball bearing has the lower coefficient of friction at any load and speed than any other bearing. It further shows that the coefficient does not vary much with differences in load, and that it varies very little with any increase in speed, thus, giving to it all the desirable features of a shating bearing.

Bearing "C", the babbitt bearing showed itself to be next best at the low speeds, but, as soon as the speeds increased beyond five or six hundred R.P.M., Bearing "A", the duplex roller bearing showed itself to be better. Bearing "A" was very nearly as good as the babbitt at low speeds and very much better at high speeds, it being the only bearing which we could run at much more than 2000 R.P.M. It showed itself to be similar to the ball bearing because its curve was flat at all



loads and speeds. So for this reason, we should say that it was the second best bearing we tested.

At the low loads and low speeds, Bearing "B", the spiral roller bearing, showed itself to be the poorest of all, and at high speeds it had a tendency to increase its coefficient of friction to infinity.

Bearing "E", the third roller bearing was fairly good at low speeds, but, poor at high speeds. It did not vary to any great extent for the difference in load, but, as a whole the coefficient of friction was far too high.

Bearing "D" also showed its superiority by virtue of the fact that it took less power to drive it at any speed and load than any other bearing.

Bearings "A", "B", "C" and "E" showed themselves to take about the same power to drive at low speeds, although, Bearing "A" may be given the preference since it requires less power at the low speeds than the others.

1. The first part of the paper is devoted to a general discussion of the problem of the existence of a solution of the system of equations

$$\frac{dx}{dt} = f(x, y, z), \quad \frac{dy}{dt} = g(x, y, z), \quad \frac{dz}{dt} = h(x, y, z),$$

where f, g, h are continuous functions of x, y, z and satisfy certain conditions.

2. In the second part we consider the case when the functions f, g, h are linear in x, y, z .

3. The third part is devoted to the study of the stability of the solutions of the system.

4. In the fourth part we consider the case when the functions f, g, h are periodic in t .

5. The fifth part is devoted to the study of the asymptotic behavior of the solutions of the system.

6. In the sixth part we consider the case when the functions f, g, h are analytic in x, y, z .

7. The seventh part is devoted to the study of the bifurcation of the solutions of the system.

8. In the eighth part we consider the case when the functions f, g, h are piecewise continuous in t .

9. The ninth part is devoted to the study of the qualitative properties of the solutions of the system.

10. In the tenth part we consider the case when the functions f, g, h are bounded in x, y, z .

11. The eleventh part is devoted to the study of the global properties of the solutions of the system.

12. In the twelfth part we consider the case when the functions f, g, h are convex in x, y, z .

13. The thirteenth part is devoted to the study of the topological properties of the solutions of the system.

14. In the fourteenth part we consider the case when the functions f, g, h are concave in x, y, z .

15. The fifteenth part is devoted to the study of the geometric properties of the solutions of the system.

16. In the sixteenth part we consider the case when the functions f, g, h are homogeneous in x, y, z .

17. The seventeenth part is devoted to the study of the algebraic properties of the solutions of the system.

18. In the eighteenth part we consider the case when the functions f, g, h are separable in x, y, z .

19. The nineteenth part is devoted to the study of the combinatorial properties of the solutions of the system.

20. In the twentieth part we consider the case when the functions f, g, h are symmetric in x, y, z .

At the high speeds and high loads, Bearing "A" also showed up well, although, very little better than the babbitt.

Bearing "B" and "E" showed up well on the low speeds only, but, an increased speed caused their friction to increase rapidly.

All the curves showed that the horse power necessary to drive increased with the load and increased with the speed.

Arthur Kutzinger
Arthur S. Kuter

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